ZooKeys 5: 1-32 (2009)
doi: 10.3897/zookeys.5.54
www.pensoftonline.net/zookeys

RESEARCH ARTICLE

A peer-reviewed open-access journal
ZooKeys
Launched to accelerate biodiversity research

# Seven species of *Pseudopecoeloides* Yamaguti, 1940 (Digenea, Opecoelidae) from temperate marine fishes of Australia, including five new species

Thelma O. Aken'Ova [1,2,†], Thomas H. Cribb [1,‡], Rodney A. Bray [3,§]

**1** *Department of Microbiology and Parasitology, The University of Queensland, Brisbane, Australia* **2** *Department of Biological Sciences, Ahmadu Bello University, Zaria, Kaduna State, Nigeria* **3** *Department of Zoology, Natural History Museum, London, UK*

† *urn:lsid:zoobank.org:author:1E914443-9180-46FC-AB66-1B5C11AF5152*
‡ *urn:lsid:zoobank.org:author:325DB589-56F9-4F65-A456-A0AA4A0A39FD*
§ *urn:lsid:zoobank.org:author:C053AFDE-D221-4BE1-9B0A-30307A67D4C0*

Corresponding author: *Rodney A. Bray* (rab@nhm.ac.uk)

Academic editor: *David Gibson* | Received 13 October 2008 | Accepted 1 January 2009 | Published 16 February 2009

*urn:lsid:zoobank.org:pub:3CB53927-ADD1-4012-9088-F25315621 5A2*

**Citation:** Aken'Ova TO, Cribb TH, Bray RA (2009) *Pseudopecoeloides* Yamaguti, 1940 (Digenea, Opecoelidae) from temperate marine fishes of Australia. ZooKeys 5: 1-32. doi: 10.3897/zookeys.5.54

## Abstract

Seven species of *Pseudopecoeloides* Yamaguti, 1940, including five new are described from marine fishes in the waters off the coasts of Queensland and both Western and South Australia. The new species are *Pseudopecoeloides hickmani* **sp. n.** from *Pseudocaranx wrighti*, *Pseudopecoeloides lesteri* **sp. n.** from *Pseudocaranx dentex* and *Pseudocaranx wrighti*, *Pseudopecoeloides arripi* **sp. n.** from *Arripis georgianus*, *Pseudopecoeloides atherinomori* **sp. n.** from *Atherinonmorus ogilbyi* and *Pseudopecoeloides hafeezullahi* **sp. n.** from *Trachurus novaezealandiae*. *Pseudopecoeloides scomberi* Hafeezullah, 1971, which was transferred to *Opecoeloides* Odhner, 1928 by Madhavi (1975), is reported from *Scomberoides lysan* and returned to *Pseudopecoeloides*. *Pseudopecoeloides tenuis* Yamaguti, 1940 is reported from a new host species, *Priacanthus macracanthus*. The Carangidae is the dominant host family for species of *Pseudopecoeloides*, followed by the Mullidae, Priacanthidae and Champsodontidae.

## Keywords

Digenea, Opecoelidae, *Pseudopecoeloides*, *Pseudopecoeloides hickmani* sp. n., *Pseudopecoeloides lesteri* sp. n., *Pseudopecoeloides arripi* sp. n., *Pseudopecoeloides atherinomori* sp. n., *Pseudopecoeloides hafeezullahi* sp. n., South Australia, Western Australia, Queensland, fishes, Carangidae, Arripidae, Atherinidae, Priacanthidae

Copyright *Thelma O. Aken'Ova* et al. This is an open access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

## Introduction

In erecting *Pseudopecoeloides* Yamaguti, 1940 for *P. tenuis* Yamaguti, 1940 from the priacanthid *Pseudopriacanthus nipponicus* (Cuv. & Valenc.) [*sic* – ? *Pristigenys niphonius* Cuvier, Japanese bigeye], Yamaguti (1940) observed that the caecal ends were connected to the excretory vesicle (i.e. forming a uroproct). He re-examined the specimens of *Cymbephallus carangis* Yamaguti, 1938 and, finding a uroproct, transferred it to *Pseudopecoeloides*.

*Pseudopecoeloides* is a well established genus, containing elongate and slender worms with a pedunculate, non-papillate ventral sucker and a uroproct. All nominal species conform to this concept, except *Pseudopecoeloides equesi* Manter, 1947. *P. equesi* was described as bearing five distinct papillae on its ventral sucker and, in his original discussion, Manter (1947) thought that it could well represent a new genus. This species was transferred to *Dactylomyza* by Aken'Ova (2003).

Yamaguti (1971) listed ten species of *Pseudopecoeloides*, but later when Bartoli et al. (2003) devised a key to the species, they included 18 species. These are listed below in our discussion of our division of the genus into two groups.

The data presented below are for seven species recovered from temperate marine fishes in Australian waters. Fishes of four families are reported as hosts for these species, four from the Carangidae (trevallies, horse mackerel and queenfish) and one each from the Priacanthidae (big-eyes), Arripididae (ruff) and Atherinidae (hardyheads).

## Materials and methods

Fish hosts discussed in this study were collected, mainly by angling or seining, from various sites in Moreton Bay in southeastern Queensland, around Fremantle, Coogee and Woodman Point in Western Australia and off Kangaroo Island, South Australia. Opecoelids were collected live from fish as soon as they had died or been anaesthetised. The worms were washed in cold saline, then fixed in hot saline and preserved in 5% formalin. Whole-mounts were prepared by staining in Mayer's acid haematoxylin, dehydrating in ethanol, clearing in methyl salicylate and then mounting in Canada balsam. Because of their pedunculate ventral sucker, the worms were mounted laterally or ventro-laterally. Measurements were taken using a computerised digitising system similar to that described by Roff and Hopcroft (1986) and recorded in micrometres as ranges followed by the means in parentheses. The length of the forebody was taken from the anterior extremity of the body to the lateral margin of the ventral sucker peduncle. In laterally mounted worms, the greatest dimension across the oral and ventral suckers was taken as the width and the depth as the length. The length of the ventral sucker peduncle was taken from the distal extremity to its point of attachment to the body. Figures were prepared with the aid of a drawing tube mounted on an Olympus BH2 microscope. Abbreviations: BMNH, the British Museum (Natural History) Collection at the Natural History Museum, London, UK; QM, Queensland Museum Collection, Brisbane, Australia.

## Results

### Family Opecoelidae Ozaki, 1925
### Subfamily Opecoelinae Ozaki, 1925

### Genus *Pseudopecoeloides* Yamaguti, 1940
urn:lsid:zoobank.org:act:B8D615C7-F0AD-4E84-BF2C-64F7BEA66682

Species of *Pseudopecoeloides* can be divided into two morphological groups based on their sucker ratios, as follows:

**Group A.** Species with the oral sucker larger than the ventral sucker: *P. tenuis* Yamaguti, 1940 from Priacanthidae and Carangidae, in the Indo-West Pacific Region and Great Australian Bight; *P. tenuoides* Martin, 1960 from Priacanthidae and Acanthuridae, off Hawaii; *P. boops* Yamaguti, 1970 from Priacanthidae and Champsodontidae, off Hawaii and Mozambique; *P. opelu* Yamaguti, 1970 from the mackerel scad *Decapterus macarellus* (Cuvier), Carangidae, off Hawaii; *P. parviacetabulus* Yamaguti, 1970 from the bigeye scad *Selar crumenophthalmus* (Bloch), Carangidae, off Hawaii; *P. wekeula* Yamaguti, 1970 from Mullidae and Chaetodontidae, off Hawaii and the Seychelles; *P. chloroscombri* (Fischthal & Thomas, 1970) Bartoli, Gibson & Bray, 2003 from the Atlantic bumper *Chloroscombrus chrysurus* Girard and horse mackerels *Trachurus* spp., Carangidae, Western Mediterranean Sea, eastern Atlantic Ocean; *P. orientalis* Gupta & Ahmad, 1978 from the longbarbel goatfish *Parupeneus macronemus* (Lacepède), Mullidae, Bay of Bengal; *P. puriensis* Ahmad, 1978 from *Parupeneus macronemus*, Mullidae, Bay of Bengal; *P. psettodi* Parukhin, 1983 from the Indian spiny turbot *Psettodes erumei* (Bloch & Schneider), Psettodidae, Mozambique Channel; and *P. astrocongeneris* Shen, 1989 from the whitespotted conger *Conger myriaster* (Brevoort), Congridae, East China Sea; *P. dayawanensis* Shen & Tong, 1990 from the Malabar trevally *Carangoides malabaricus* (Bloch & Schneider), Carangidae, South China Sea; and *P. capucini* Toman, 1992 from *Pseudupeneus* sp., Mullidae, off Seychelles.

**Group B.** Species with the oral sucker the same size as or smaller than the ventral sucker: *P. carangis* (Yamaguti, 1938) mainly from Carangidae, but also recorded in Champsodontidae, Gempylidae, Mullidae, Polynemidae, Sciaenidae and Sphyraenidae, widespread in tropical and subtropical warm waters of all oceans; *P. gracilis* Manter, 1947 from Carangidae (mainly) and Apogonidae, Gulf of Mexico and adjacent waters; *P. akule* Yamaguti, 1970 from Carangidae and Champsodontidae, off Hawaii and Mozambique; *P. scomberi* Hafeezullah, 1971 from *Scomberoides* spp., Carangidae, off India and Malaysia; and *P. mugilis* Shen, 1990 from the largescale mullet *Liza macrolepis* (Smith), Mugilidae, South China Sea.

**Comment:** In describing some new species, Yamaguti (1970) stated that the relative positions of the ovary and the testes were consistent and useful in the separation of species, except in contracted specimens. This view is followed here, and, in addition, the extent of the post-testicular area has been found to be a useful criterion.

## *Pseudopecoeloides tenuis* Yamaguti, 1940

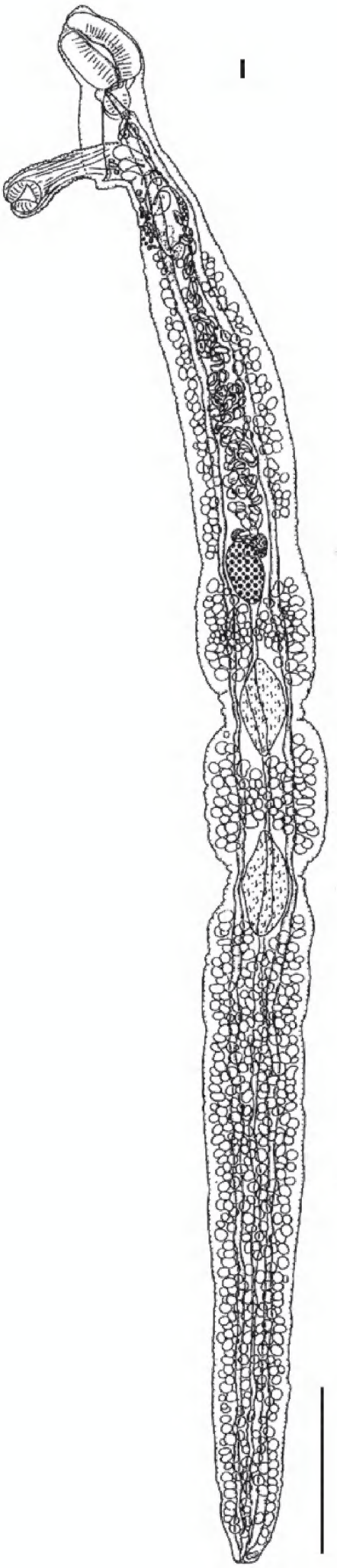
**Host:** *Priacanthus macracanthus* Cuvier (Priacanthidae: Perciformes), red bigeye.
**Localities:** Moreton Bay: Off Tangalooma 27°14'S, 153°19'E; off Shorncliffe 27°21'S, 153°07'E.
**Site:** Pyloric caeca, intestine.
**Material studied:** 11 adults. Moreton Bay, Queensland: 6 off Tangalooma, February 1993; 5 off Shorncliffe, March and April 1995.
**Voucher specimens:** QM G230433- G230441; BMNH 2008.12.9.44-50.

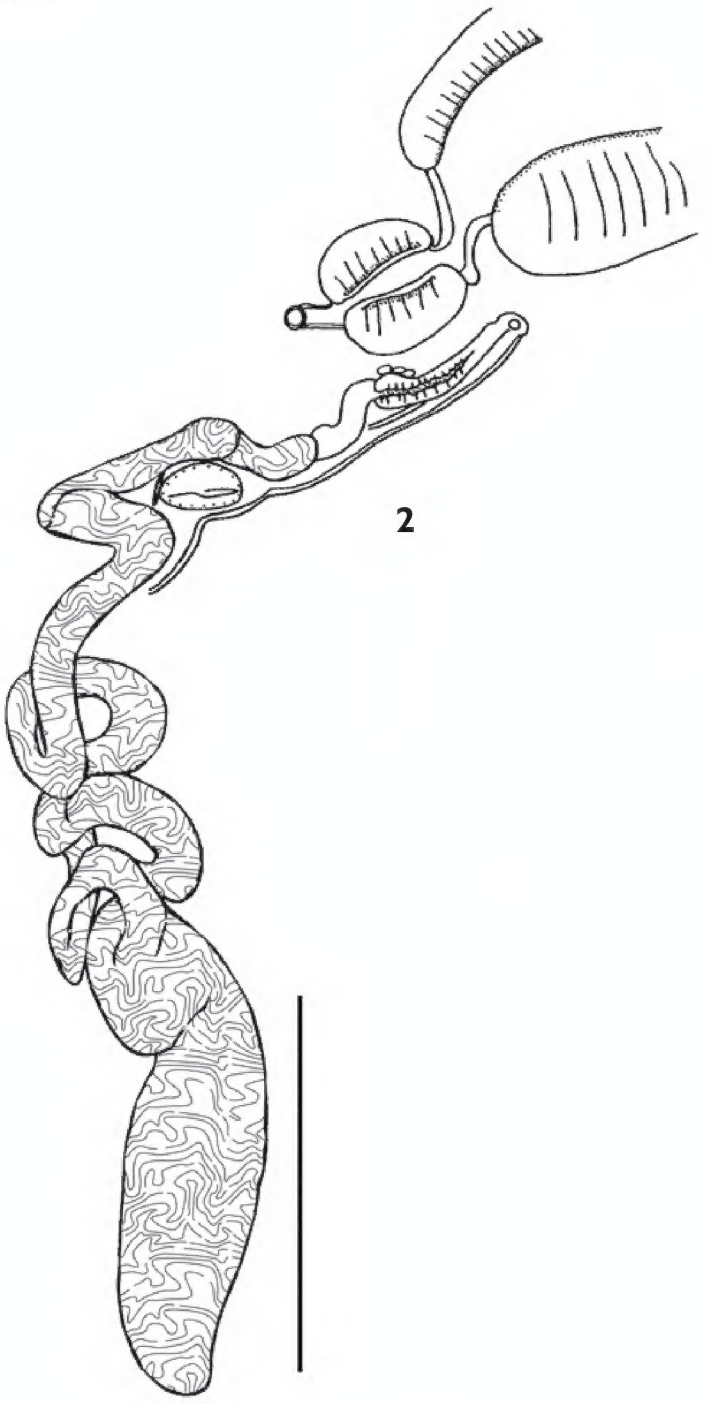
**Description** (Figures 1-3): Based on 8 gravid whole-mounts and 3 sets of serial sections. Measurements are of 8 gravid, unflattened, laterally and dorso-ventrally mounted worms.

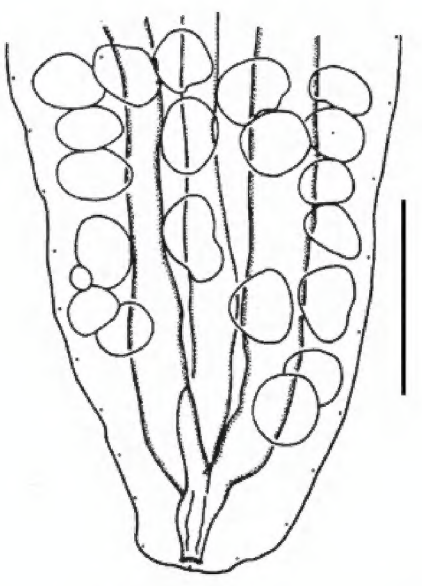
Body elongate, slender, more or less dorso-ventrally flattened, with 3 distinct constrictions adjacent to gonads; maximum width in region of gonads, 3,600-5,864 (4,468) × 225-450 (340); width to length ratio 1:10.9-17.7 (14.0). Oral sucker oblong, ventrally subterminal, 225-311 (257) × 135-214 (175). Ventral sucker pedunculate, spherical to subspherical, smaller than oral sucker, 91-113 (102) × 94-117 (104); sucker width ratio 1:0.5-0.8 (0.6). Ventral sucker peduncle moderately long, retractile, 238-454 (353) × 123-156 (137), 5.3-11.1 (8.0) % of body length. Forebody short, 331-425 (379), 6.6-10.4 (8.7) % of body length; peduncle to forebody length ratio 1:0.8-1.6 (1.1). Prepharynx distinct, very short. Pharynx distinct, spherical to subspherical, 75-110 (88) × 84-100 (90). Oesophagus very short, looped. Caeca long, narrow, clearly visible at body constrictions, unite with excretory vesicle close to posterior end of body to form uroproct.

Testes 2, entire, fusiform, tandem, separate, in middle third of body; anterior 250-428 (319) × 136-214 (166); posterior 275-408 (330) × 143-227 (174). Post-testicular area 1,044-2,057 (1,582) long, 29-40 (35) % of body length. Cirrus-sac absent. Seminal vesicle long, sinuous anteriorly; expanded posterior portion 227-402 (300) × 65-130 (93). Pars prostatica distinct, thick-walled, surrounded by gland-cells. Ejaculatory duct short, narrow. Genital atrium indistinct. Genital pore antero-sinistral to intestinal bifurcation, level with or anterior to posterior margin of oral sucker, 207-246 (224) from anterior extremity, 5.8-4.2 (5.0) % of body length.

Ovary oval, entire, directly anterior to anterior testis, 163-220 (192) × 100-156 (127). Mehlis' gland, anterior to ovary. Uterine seminal receptacle occupies posterior coils of uterus. Laurer's canal passes postero-ventrally and opens dorsally at level of anterior margin of ovary. Uterus usually coils intercaecally between anterior margin of ovary and posterior expanded portion of seminal vesicle, then passes to genital aperture with little or no coiling. Metraterm indistinct, thin-walled, with anterior extremity surrounded by gland cells. Eggs relatively small, numerous, oval, operculate, 39-54 (47) × 25-34 (28). Vitelline follicles restricted to area posterior to ventral sucker, extend from 700-925 (801) from anterior extremity, 14.7-25.7 (18) % of body length, to 18-72 (39) from posterior extremity, with bilateral in-




**Figs 1-3.** *Pseudopecoeloides tenuis* Yamaguti, 1940 ex *Priacanthus macracanthus.* 1. Whole-mount latero-ventral view. 2. Terminal genitalia. 3. Ventral view of posterior end showing uroproct. *Scale bars*: 1, 500 µm; 2, 200 µm; 3, 100 µm.

terruptions at level of each gonad at points of constriction; follicles in 2 separate fields ventrally in uterine area; fields confluent dorsally in uterine, intergonadal and post-testicular regions, lateral, dorsal and ventral to caeca except in areas adjacent to gonads; anterior limit variously overlaps expanded posterior portion of seminal vesicle.

Excretory pore terminal. Excretory vesicle tubular, I-shaped, passes anteriorly to terminate at point just anterior to posterior margin of ovary.

**Comments:** Except for a few slight morphological differences, the present material is almost identical to *P. tenuis,* as originally described. The differences observed between the present material and that of Yamaguti (1940) include: a longer forebody relative to the body length (6.6-10.4 (8.7) versus 5.1%); smaller eggs measuring 39-54 × 25-34 (47 × 28) versus 54-60 × 33-39; and a genital pore which is more posteriorly situated, at 3.8-6.1 (5.1) % compared with 3.1% of the body length from the anterior extremity. Although the difference in egg size is significant, it is not surprising, since Yamaguti measured the eggs from live worms. The other differences are most likely as a result of fixation and may therefore not be taxonomically significant. Moreover, the present material and Yamaguti's are both from priacanthids.

*Pseudopecoeloides tenuis* is similar to *P. tenuoides* in almost every metrical feature and in the bilateral constrictions adjacent to the gonads observed in Yamaguti's material and the present material. This resemblance was also noted by Martin (1960), but he separated the species on the basis of egg size (smaller in *P. tenuoides*), the sizes of the suckers (smaller in *P. tenuoides*) and on the occurrence of pads on the ventral sucker in *P. tenuoides*. The present material is very similar to *P. tenuoides* and does not exhibit the differences observed by Martin (1960) between his worm and Yamaguti's *P. tenuis*. The difference in egg size probably resulted from the fact that Yamaguti measured the eggs of *P. tenuis* from live material, whereas the egg measurements of *P. tenuoides* were probably taken from permanent mounts. The only noticeable differences between the present material and *P. tenuoides* are that the latter has a larger oral sucker relative to the pharynx, reflected by a ratio of 1:2.8 versus 1:1.5-2.4 (1.9) [1.8], and it has pads in its ventral sucker. Yamaguti (1970) also observed the pads described by Martin (1960) in *P. tenuoides* in the material he examined from the glasseye *Heteropriacanthus cruentatus* (Lacepède) (Priacanthidae) (the type-host) and the bluelined surgeonfish *Acanthurus nigroris* Valenciennes (Acanthuridae) off Hawaii (type-locality). No similar pads were observed in the present material, although, if they occurred, it would have been difficult if not impossible to see them, since our worms were mostly mounted laterally. This feature needs to be investigated further before a decision regarding the status of *P. tenuoides* can be taken.

*P. tenuis* is widespread in the Indo-Pacific region and is reported in the Great Australian Bight (Lebedev, 1968), off New Zealand (Manter, 1954; Korotaeva, 1975) and off New Caledonia (Bray and Justine, 2008)

***Pseudopecoeloides hickmani* Aken'Ova, Cribb & Bray, sp. n.**
urn:lsid:zoobank.org:act:E746A0FA-213E-40BC-8F23-FB350658E8DD

**Type-host:** *Pseudocaranx wrighti* (Whitley) (Carangidae: Perciformes), skipjack trevally.

**Type-locality:** Off North Mole, Fremantle, Western Australia, 32°03′S, 115°43′E, December 1994.

**Site:** Intestine, pyloric caeca, rectum.

**Material studied:** 8.

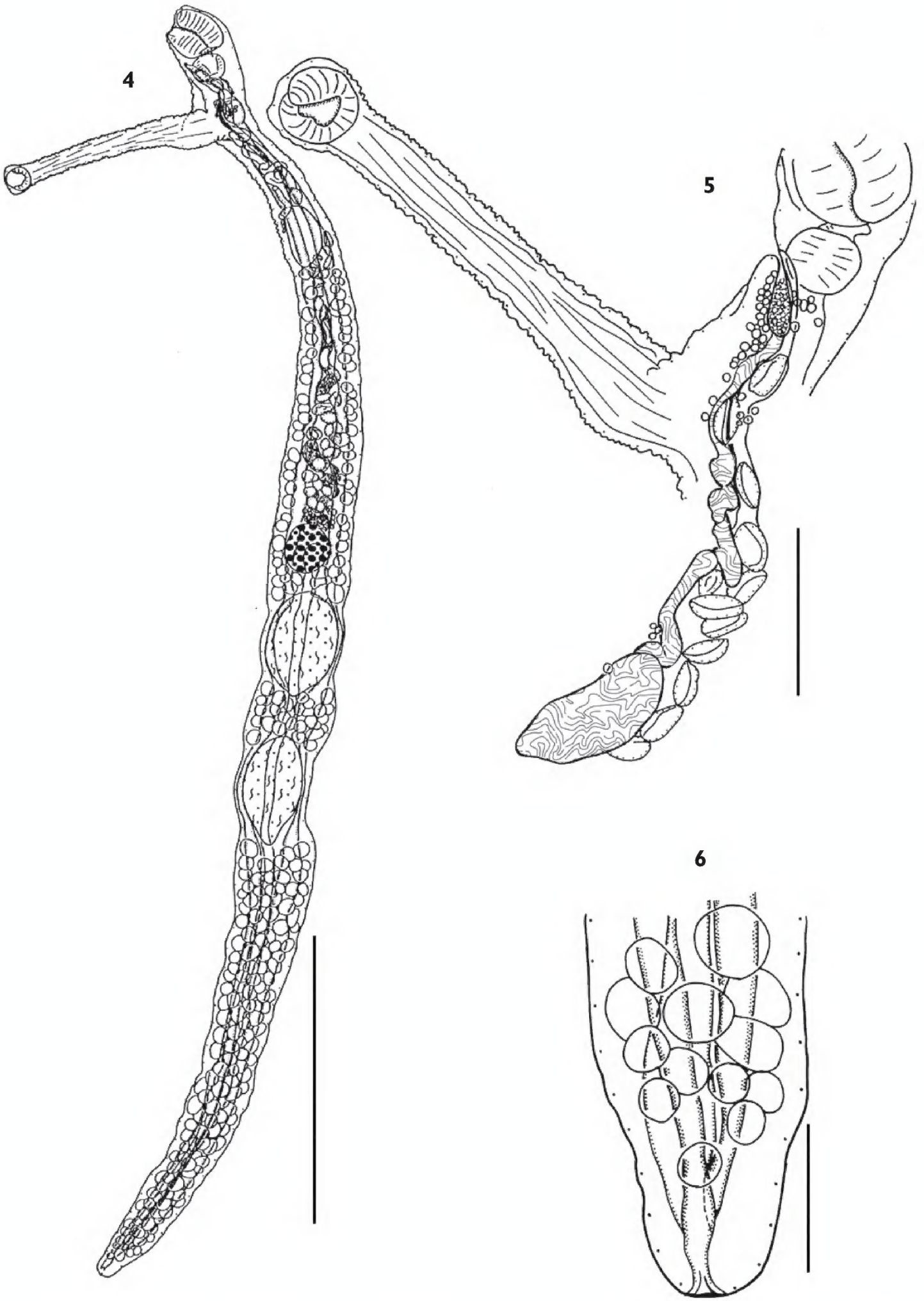
**Type-material:** Holotype: Queensland Museum, Reg. No. QM G230442, paratypes: Queensland Museum, Reg. Nos QM G230443-230451, BMNH Reg. Nos 2008.12.9.1-6.

**Description** (Figures 4-6): Based on 7 gravid, unflattened, laterally and dorso-ventrally mounted whole-mounts and 1 set of serial sagittal sections. Measurements are of the 7 gravid, unflattened, laterally and dorso-ventrally mounted worms.

Body elongate, slender, subcylindrical, tapers gradually to narrow point posteriorly, rounded at anterior end; maximum width in region of gonads, 3,204-4,929 (4,213) × 205-301 (249); width to length ratio 1:15.6-19.2 (17.0). Oral sucker subspherical, ventrally subterminal, 131-175 (159) × 112-155 (134). Ventral sucker pedunculate, close to anterior extremity, smaller than oral sucker, subspherical, 71-79 (73) × 78-92 (85); sucker width ratio 1:0.5-0.8 (0.6). Ventral sucker peduncle 425-863 (650) × 97-109 (102) wide, 13.3-17.5 (15.3) % of body length. Forebody short, containing numerous gland cells, 337-399 (362) long, 7.7-10.5 (8.7) % of body length; peduncle to forebody length ratio 1:0.4-0.8 (0.6). Prepharynx distinct, feebly developed, very short. Pharynx subspherical, wide, 66-89 (79) × 71-101 (87); pharynx to oral sucker width ratio 1:1.4-1.6 (1.5). Oesophagus relatively short, thick-walled. Intestinal bifurcation close to anterior end, dorsal to ventral sucker peduncle, 49-98 (68) posterior to anterior margin of ventral sucker peduncle. Caeca long, narrow, unite with excretory vesicle close to posterior extremity to form uroproct.

Testes 2, entire, may be subspherical or broadly fusiform, separate, tandem, in posterior half of body; anterior 273-396 (335) × 169-246 (210); posterior 298-383 (350) × 164-257 (203). Post-testicular area 1,005-1,639 (1,472) long, 31.4-37.1 (34.9) % of body length. Cirrus-sac absent. Seminal vesicle tubular, long and sinuous anteriorly, large and saccular posteriorly, extends from point level with, anterior to or posterior to anterior margin of ventral sucker peduncle to point variously between posterior margin of peduncle and anterior margin of ovary; posterior saccular portion 156-278 (202) × 54-106 (84). Pars prostatica distinct, large, elongate, with openings of numerous ducts, surrounded by gland cells. Ejaculatory duct short. Genital atrium large. Genital pore antero-sinistral to intestinal bifurcation, about half way between anterior and posterior margins of pharynx, 184-213 (197) from anterior end, 4.0-5.9 (4.7) % of body length.

Ovary pre-testicular, entire, subspherical, 116-197 (163) × 129-168 (142). Mehlis' gland distinct, anterior to ovary. Uterine seminal receptacle present. Laurer's canal present, thick-walled, opens slightly anterior to or posterior to anterior margin of ova-




**Figs 4-6.** *Pseudopecoeloides hickmani* sp. n. ex *Pseudocaranx wrighti*. 4. Whole-mount latero-ventral view. 5. Terminal genitalia. 6. Ventral view of posterior end showing uroproct. *Scale bars*: 4, 1mm; 5, 200 µm; 6, 100 µm.

ry, at point dorsally antero-sinistral to ovary, close to lateral margin of worm. Uterine coils occupy area between point anterior to anterior margin of ovary and various levels posterior to posterior tip of seminal vesicle, overlapping caeca ventrally, then following course of seminal vesicle to open into genital atrium. Metraterm indistinct. Eggs oval, operculate, 44-71 (55) × 20-42 (26). Vitelline follicles restricted to hindbody, extend from 793-1,137 (919) from anterior extremity, 20.4-24.8 (21.9) % of body length, to 33-64 (49) from posterior extremity; fields lateral, ventral and dorsal to caeca, confluent dorsally and ventrally in post-testicular and inter-testicular areas, and dorsally in pre-ovarian region, interrupted at level of anterior and posterior testes; anterior limit usually slightly overlaps seminal vesicle, sometimes slightly posterior to it (n=2), occasionally at level of posterior margin of seminal vesicle (n=1), or to point just posterior to anterior margin of large distended portion of seminal vesicle (n=1).

Excretory pore terminal to slightly dorsally subterminal. Excretory vesicle I-shaped, long, tubular, reaches anteriorly to overlap posterior margin of ovary, terminates at point anterior to mid-body.

**Etymology:** This species is named for V. V. Hickman in recognition of his contribution to the systematics of marine digeneans in the Australian region.

**Comments:** Specimens of *Pseudopecoeloides hickmani* sp. n. have an oral sucker greater than the ventral sucker, placing the species in Group A. It can be distinguished from members of this group as follows: it has a greater length/width ratio than *P. tenuis*, *P. psettodi, P. capucini* and *P. wekeula*; and it has a smaller pharynx than *P. tenuis*, a larger pharynx than *P. psettodi, P. capucini* and *P. wekeula*, relative to the size of the oral sucker (Table 1). The ventral sucker peduncle in the new species is longer than that of *P. tenuis* relative to the length of the forebody; its forebody is shorter and its post-testicular area longer relative to the length of the body than those of *P. wekeula* and *P. capucini*. *P. hickmani* sp. n. closely resembles *P. opelu* in most of its metrical features and by the fact that they are both from carangids, but it can be distinguished from the latter by its more elongate form with a width to length ratio of 1:17 versus 1:11, a slightly larger pharynx with a pharynx to oral sucker width ratio of 1:1.5 versus 1:1.8 and a longer post-testicular area measuring 31.4-37.1 (34.9) versus 21.3% of the body length.

***Pseudopecoeloides lesteri* Aken'Ova, Cribb & Bray, sp. n.**
urn:lsid:zoobank.org:act:D5F80409-0968-4CFD-BC49-C8471ED6B9A2

**Type-host:** *Pseudocaranx dentex* (Bloch & Schneider)(Carangidae: Perciformes), white trevally.

**Other host:** *Pseudocaranx wrighti* (Whitley) (Carangidae: Perciformes), skipjack trevally.

**Type-locality:** Off Kingscote, Kangaroo Island, South Australia, 35°40'S, 137°39'E, December 1995.

**Other locality:** Off North Mole, Fremantle, Western Australia, 32°03'S, 115°43'E, December 1994.

**Table 1.** *Pseudopecoeloides* species (not immediately distinguishable from the other species) in **Group A** – Species with oral sucker larger than ventral sucker.

| **Species** | ***P. psettodi*** | ***P. capucini*** | ***P. wekeula*** | ***P. opelu*** | ***P. chloroscombri*** | ***P. arripi* sp. n.** | ***P. hickmani* sp. n.** | ***P. hafeezullahi* sp. n.** |
|---|---|---|---|---|---|---|---|---|
| No. examined | ?? | 10? | 42 | 25 | 20 | 10 | 7 | 10 |
| Reference | Parukhin (1983) | Toman (1982) | Yamaguti (1970) | Yamaguti (1970) | Bartoli et al. (2003) | This study, from Western Australia | This study | This study |
| Length | 3,100 | 5,250-6,780 | 1,500-4,800 | 1,400-3,600 | 2,907-7,060 | 2,161-4,152 | 3,204-4,929 | 2,452-3,564 |
| Width | 220 | 530-730 | 180-500 | 140-400 | 253-514 | 210-347 | 205-301 | 226-321 |
| Mean | | | | | 4,470 × 374 | (3,361 × 280) | (4,213 × 249) | (3,026 × 274) |
| Length/Width | 14.1*; 9.5* | 8.6* | 8.5* | 11.0* | 11.95* | 9.3 -14.0 | 15.6-19.2 | 8.9-12.6 |
| Mean | | | | | | (12) | (17.0) | (11.1) |
| Oral sucker length | | 180-200 | 100-210 | 60-190 | 163-266 | 129-221 | 131-175 | 128-163 |
| Oral sucker width | | 170-210 | 100-200 | 60-200 | 173-262 | 114-179 | 112-155 | 110-169 |
| Mean | | | | | (210 × 220) | (65 × 145) | (159 × 134) | (147 × 141) |
| Ventral sucker length | | 130-140 | 70-130 | | 100-138 × | 73-94 | 71-79 | 85-111 |
| Ventral sucker width | | 130-170 | 95-160 | 60-150 | 122-176 | 82-108 | 78-92 | 96-110 |
| Mean | | | | | (124 × 154) | (84 × 91) | (73 × 85) | (96 × 105) |
| V.S./O.S. Width | 0.6* | 0.6* | 0.7* | 0.6* | 0.54-0.86 (0.73) | 0.5-0.7 (0.6) | 0.5-0.8 (0.6) | 0.6-0.9 (0.7) |
| Pharynx length | | 130-150 | 50-150 | 50-150 | 131-173 | 59-105 | 71-101 | 85-115 |
| Pharynx width | | 110-140 | 50-140 | 50-140 | 106-166 | 70-109 | 116-197 | 99-122 |
| Mean | | | | | (154 × 131) | (85 × 94) | (87 × 163) | (99 × 111) |
| O.S./pharynx W. | 2.9* | 1: 1.7* | 2.0* | 1.8* | *1.18 | 1.4-1.8 (1.5) | 1.4-1.6 (1.5) | 1.1-1.4 (1.3) |
| Forebody L. | | | | | 270-616 (442) | 288-409 (344) | 337-399 (362) | 299-465 (384) |
| Forebody% Body L. | 7.3* | 12.3* | 14.6* | 11.8* | | 8.9-14.6 (10.4) | 7.7-10.5 (8.7) | 11.0-15.3 (12.9) |

| Species | *P. psettodi* | *P. capucini* | *P. wekeula* | *P. opelu* | *P. chloroscombri* | *P. arripi* sp. n. | *P. hickmani* sp. n. | *P. hafeezullahi* sp. n. |
|---|---|---|---|---|---|---|---|---|
| Post-testicular region (PTR) | | | | | 1,092-2,203 (1,618) | 633-1323 (1054) | 1005-1639 (1472) | 797-1159 (971) |
| PTR % body L. | 25.5* | 28.4* | 25.7* | 21.3* | *36.2 | 27.8-35.2 (31.4) | 31.4-37.1 (34.9) | 28.0-34.2 (32.1) |
| Eggs | 46-53 × 26 | 52-62 × 37-48 | 51-70 × 32-49 | 46-63 × 30-46 | 51-68 × 28-39 | 51-74 × 20-39 | 44-71 × 20-42 | 40-60 × 20-37 |
| Mean | | | | | (61 × 30) | (59 × 28) | (55 × 26) | (52 × 26) |
| Genital pore from anterior extremity | 5.18* | | | | | 155-220 (190) | 184-213 (197) | 142-181 (166) |
| Above as % body L. | | 4.5* | 8.2* | 7.8* | | 4.5-7.2 (5.8) | 4.0-5.9 (4.7) | 4.6-6.7 (5.5) |
| Ventral sucker peduncle % body L. | | | | | 8.3* | 10.3-16.7 (14.4) | 13.3-17.5 (15.3) | 10.1-11.8 (10.9) |
| Forebody/Ventral sucker peduncle | | | | | | 0.6-0.96 (0.73) | 0.4-0.8 (0.6) | 1.0-1.3 (1.2) |

* values derived from measuring published figures directly or calculated from published measurements.

**Site:** Intestine.

**Material studied:** Ex *Pseudocaranx dentex:* 4 off Kingscote; ex *Pseudocaranx wrighti*: 2 off North Mole.

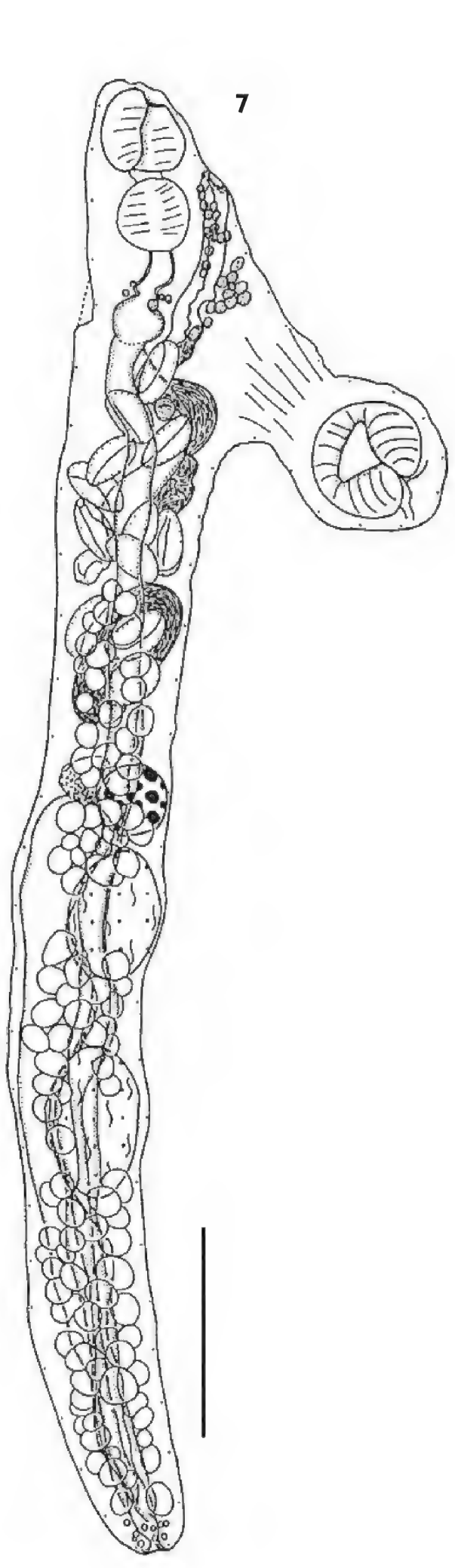
**Type-material:** Holotype: Queensland Museum, Reg. No. QM G230452, paratypes: Queensland Museum, Reg. Nos QM G230453-4, BMNH Reg. No 2008.12.9.7-8.

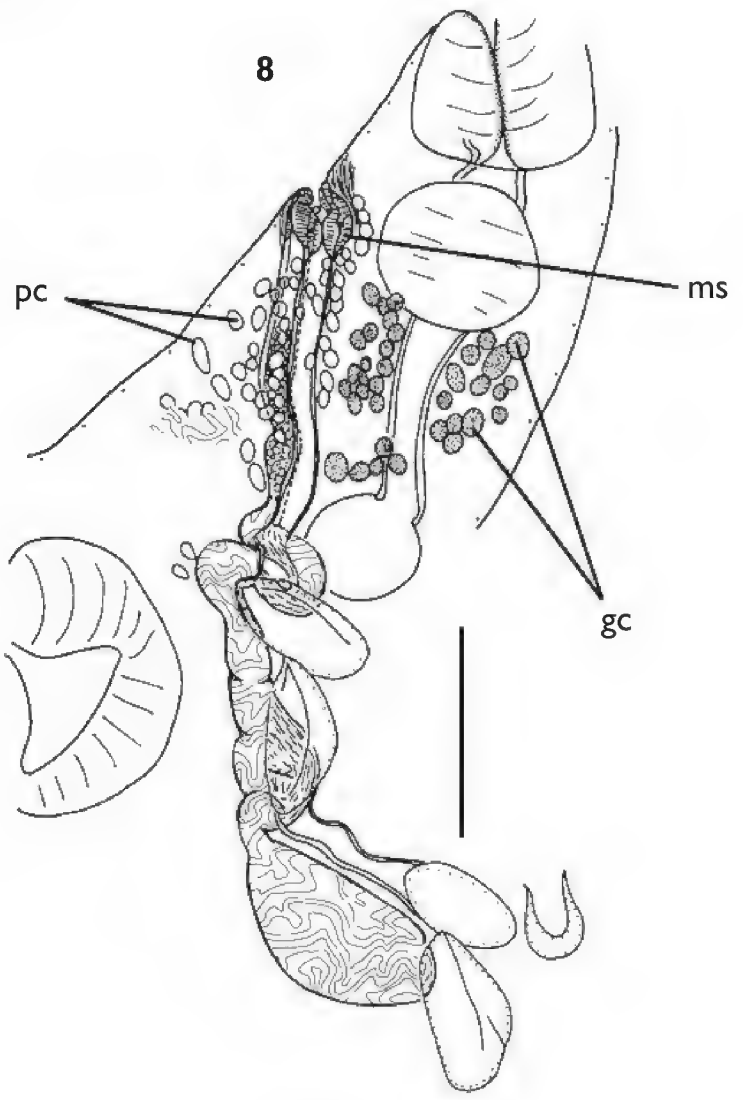
**Description** (Figures 7-11): Based on 6 gravid, unflattened, laterally mounted worms from *Pseudocaranx dentex* and *P. wrighti* and 1 set of sagittal serial sections. Measurements are based on 3 gravid, unflattened, laterally mounted specimens from *P. dentex*; measurements of worms from *P. wrighti* are given in Table 3.

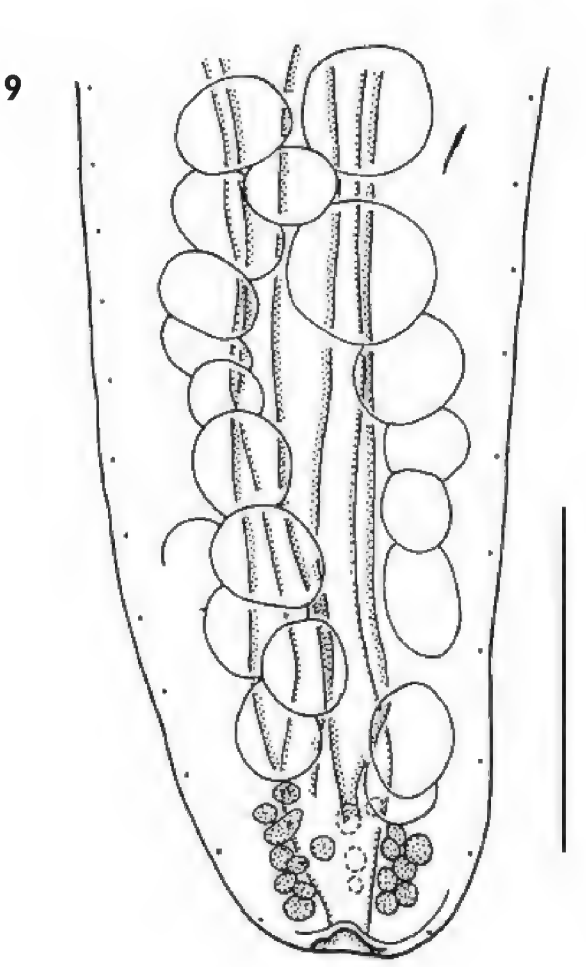
Body elongate, slender, subcylindrical; maximum width in region of gonads, 1,373-1,587 (1,482) × 158-170 (163); width to length ratio 1:8.5-10.0 (9.1). Oral sucker spherical to subspherical, opening nearly terminal, 85-95 (89) × 84-89 (86). Ventral sucker pedunculate, close to anterior end, larger than oral sucker, subspherical, 105-107 (106) × 119-125 (123); sucker width ratio 1:1.4-1.5 (1.4). Ventral sucker peduncle short, broad, 218-232 (225) × 132-158 (145), 14.6-15.9 (15.2) % of body length. Forebody relatively short, contains numerous gland cells, 261-323 (296) long, 19.0-21.7 (19.9) % of body length; peduncle to forebody length ratio 1:1.2-1.3 (1.3). Prepharynx distinct, short, feebly developed. Pharynx large, spherical to subspherical, 67-77 (72) × 76-77 (76); pharynx to oral sucker width ratio 1:1.1-1.2 (1.1). Oesophagus short, thin walled, surrounded by gland cells. Intestinal bifurcation dorsal to ventral sucker, 8-49 (28) posterior to anterior margin of ventral sucker peduncle. Caeca long, open into excretory vesicle close to posterior extremity to form uroproct (Figure 9).

Testes 2, entire, subspherical, usually separated, contiguous in one specimen, tandem, in posterior half of body; anterior 136-147 (141) × 94-125 (113); posterior 146-165 (159) × 104-129 (120). Post-testicular area 289-384 (325) long, 19.4-24.2 (21.9) % of body length. Cirrus-sac absent. Seminal vesicle long, tubular, narrow and convoluted anteriorly, large and vesicular posteriorly; posterior portion 100-107 (103) × 50-60 (55). Pars prostatica distinct, large, surrounded by gland cells. Ejaculatory duct thick-walled, with distinct sphincter at anterior extremity (see Figure 8), surrounded by gland cells. Genital atrium small. Genital pore antero-sinistral to intestinal bifurcation, close to anterior extremity, 124-133 (129) from anterior end, 8.4-9.0 (8.7) % of body length.

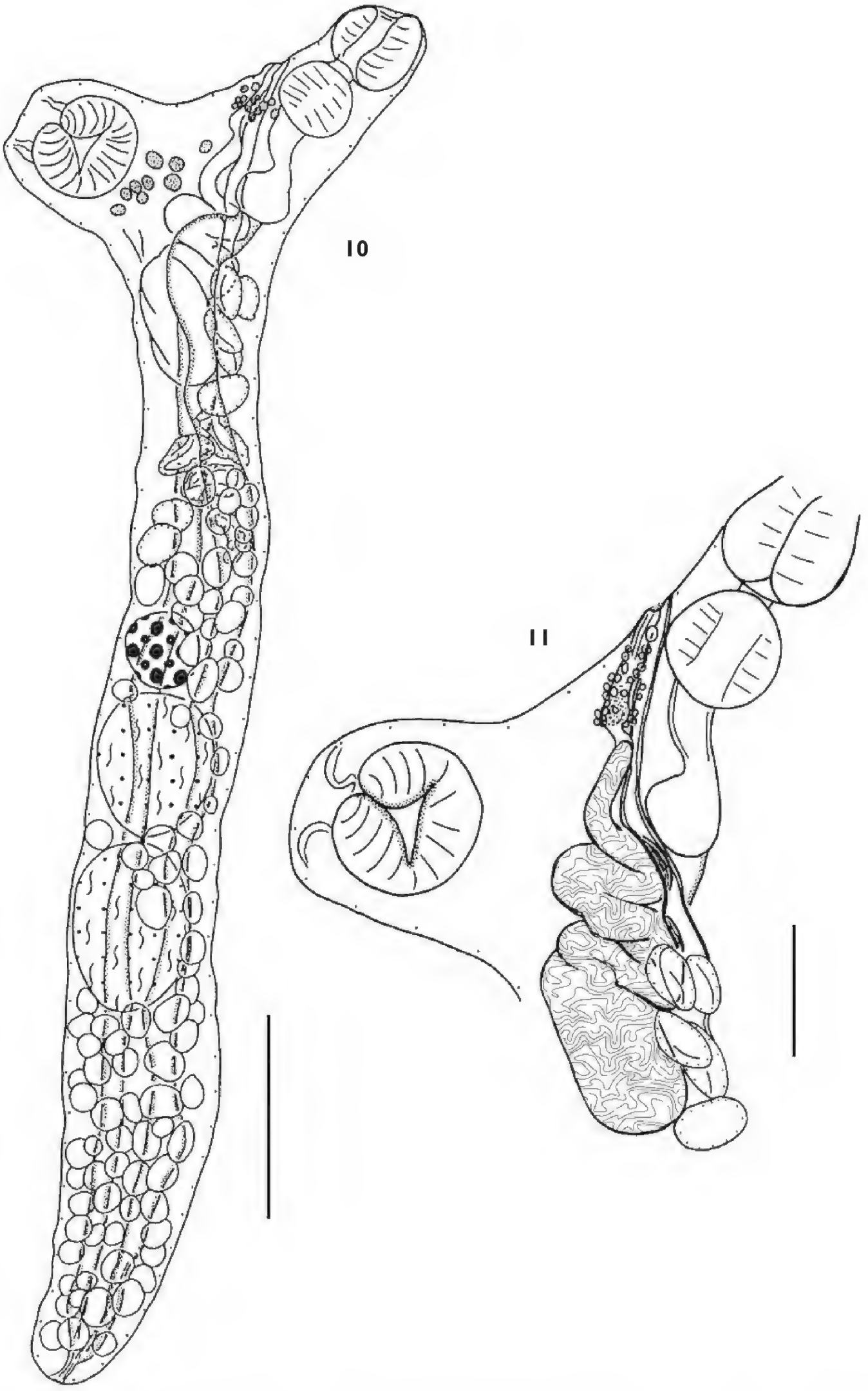
Ovary pre-testicular, entire, usually contiguous with anterior testis, separate in 1 specimen, spherical to subspherical, 71-77 (74) × 67-73 (69). Mehlis' gland distinct, anterior to antero-dorsal to ovary. Uterine seminal receptacle present. Laurer's canal present, thick-walled, opens dorso-sinistrally to ovary, at about level of its anterior margin. Metraterm distinct, thick-walled, with distinct sphincter at anterior extremity, surrounded by gland cells; thick-walled muscular structure appears to enclose anterior extremities of ejaculatory duct and metraterm (Figure 8). Eggs relatively large, operculate, 64-75 (69) × 27-44 (34). Vitelline follicles restricted to hindbody, extend from 499-623 (553) from anterior extremity, 33.8-41.9 (37.3) % of body length, to 26-40




**Figs 7-9.** *Pseudopecoeloides lesteri* sp. n. ex *Pseudocaranx dentex*. 7. Whole-mount latero-ventral view. 8. Terminal genitalia. 9, Ventral view of posterior end showing uroproct. Abbreviations: ms, muscular structure; pc, prostatic cells; gc, gland cells. *Scale bars*: 7, 250 µm; 8, 9, 100 µm.




**Figs 10-11.** *Pseudopecoeloides lesteri* sp. n. ex *Pseudocaranx wrighti*. 10. Whole-mount latero-ventral view. 11. Terminal genitalia. *Scale bars*: 10, 250 µm; 11,100 µm.

(35) from posterior extremity; fields confluent dorsally and ventrally in post-testicular area, dorsally or not between posterior margin of posterior testis and anterior limit with interruptions in areas around gonads, separate ventrally, with follicles lying lateral, ventral and dorsal to caeca; anterior limit slightly posterior to posterior margin of seminal vesicle.

Excretory pore terminal. Excretory vesicle I-shaped, long; posterior extremity forms short narrow duct surrounded by gland cells; vesicle reaches to ovary.

**Etymology:** This species is named for Professor R. J. G. Lester for his contributions to marine parasitology.

**Comments:** The specimens from *Pseudocaranx wrighti* are almost identical to those from *P. dentex* in general appearance and in all metrical features (Tables 2, 3) and are considered to be conspecific.

*Pseudopecoeloides lesteri* sp. n. can be accommodated in Group B. *P. mugilis* and *P. gracilis* can immediately be distinguished from all the other worms in the group; *P. mugilis* has the shortest post-testicular area relative to the body length and *P. gracilis* is the least elongate and has the largest ventral sucker relative to the size of the oral sucker (Table 2). *P. lesteri* can be distinguished from the remaining species by its greater sucker ratio, larger pharynx relative to the oral sucker, longer forebody and shorter post-testicular area relative to the body length. It is more elongate than *P. akule* but less so than *P. scomberi*, as shown in their length/width ratios. The genital pore of the new species is more posteriorly situated than in *P. scomberi* (Table 2).

***Pseudopecoeloides arripi* Aken'Ova, Cribb & Bray, sp. n.**
urn:lsid:zoobank.org:act:1513E213-4963-4118-9277-245BBAD29E3C

**Type-host:** *Arripis georgianus* (Valenciennes) (Arripidae: Perciformes), Australian ruff.

**Type-locality:** Off Woodman Point; Western Australia, 32°08' S 115°45' E, November and December 1994.

**Other localities:** Off Coogee Beach, Western Australia, 32°07' S 115°46' E, November and December 1994; Off Kingscote, Kangaroo Island, South Australia 35°40' S 137°39' E, December 1995.

**Site:** Intestine.

**Material studied:** Ex *Arripis georgianus*: from W.A.: 8 from Coogee Beach; 9 from off Woodman Point; 6 from S.A.: off Kingscote, Kangaroo Is.

**Type-material:** Holotype: Queensland Museum, Reg. No. QM G230455, paratypes: Queensland Museum, Reg. Nos. QM G230456- G230488, BMNH Reg. Nos. 2008.12.9.9-27.

**Description** (Figures 12-14): Based on 15 gravid, unflattened, whole-mount specimens and 2 sets of serial sagittal sections from *Arripis georgianus* off W.A. Measurements are of 10 gravid, unflattened laterally and dorso-ventrally mounted worms. Measurements of worms off S.A. are given in Table 4.

**Table 2.** *Pseudopecoeloides* species (not immediately distinguishable from the other species) in Group B – Species with the oral sucker the same size as or smaller than the ventral sucker.

| **Species** | ***P. carangis*** | ***P. gracilis*** | ***P. akule*** | ***P. mugilis*** | ***P. scomberi*** | ***P. scomberi*** | ***P. atherinomori* sp. n.** | ***P. lesteri* sp. n.** |
|---|---|---|---|---|---|---|---|---|
| No. examined | Numerous | 10 | 21 | ?? | 2 | 1 | 6 | 3 |
| Reference | Yamaguti (1938) | Manter (1947) | Yamaguti (1970) | Shen (1990) | Hafeezullah (1975) | This study | This study | This study in *Pseudocaranx dentex* |
| Length | 1,250-2,540 | 1,296-1,989 | 3,500-7,500 | 2,397 | 6,828-7,056 | 3,088 | 1,312-2,155 | 1,373-1,587 |
| Width | 220-380 | 202-352 | 200-700 | 306 | 504-583 | 288 | 146-194 | 158-170 |
| Mean | | | | | (6920 × 540) | | (1677 × 176) | (1482 × 163) |
| Length/Width | 8.4 | 5.3-6.7 | 7.7* | 7.8 | | 10.7 | 7.5-12.1 | 8.5-10 |
| Mean | | | | | 12.8¶ | | 9.6 | 9.1 |
| Oral sucker length | 125-188 | | 150-340 | | 212-221 | 154 | 84-130 | 85-95 |
| Oral sucker width | 140-200 | 97-122 | 160-360 | | 206-221 | 141 | 84-120 | 84-89 |
| Mean | | | | | (217 × 214) | | (106 × 104) | (89 × 86) |
| Ventral sucker length | 110-160 | | 200-430 | | 218-236 | 167 | 117-175 | 105-107 |
| Ventral sucker width | 125-188 | 210-260 | 200-370 | | 215-225 | 148 | 117-149 | 119-125 |
| Mean | | | | | (227 × 220) | | (142 × 134) | (106 × 123) |
| V.S./O.S. Width | 1 | 2.0-2.2 | 1.1 | 1.26 | 1 | 1 | 1.2-1.4 (1.3) | 1.4-1.5 (1.4) |
| Pharynx L. | 100-138 | 60-80 | 80-190 | 85 | 120-135 | 103 | 62-84 | 67-77 |
| Pharynx W. | 80-110 | 49-76 | 80-170 | 85 | 123-143 | 103 | 71-100 | 76-77 |
| Mean | | | | | (128 × 133) | | (70 × 85) | (72 × 76) |
| O.S./pharynx W. | 2.4* | 2.5* | 3.2* | | 1.6¶ | 1.4 | 1.2-1.4 (1.2) | 1.1-1.2 (1.1) |
| Forebody L. | | 187-240 | | | | 298 | 214-292 (258) | 261-323 (296) |
| Forebody% Body L. | 13.8* | 11.1 | 15.6* | | 8.92* | 9.7 | 13.2-0.7 (15.8) | 19.0-21.7 (19.9) |

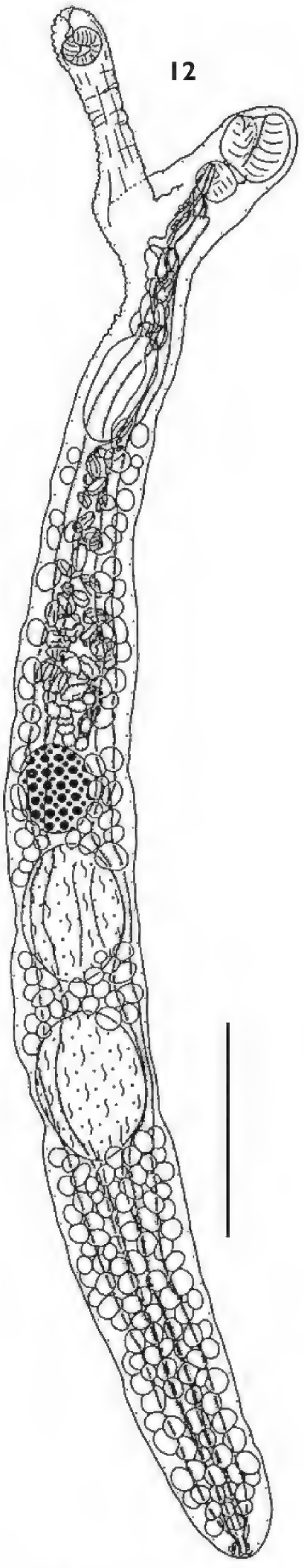
| Species | *P. carangis* | *P. gracilis* | *P. akule* | *P. mugilis* | *P. scomberi* | *P. scomberi* | *P. atherinomori* sp. n. | *P. lesteri* sp. n. |
|---|---|---|---|---|---|---|---|---|
| Post-testicular region (PTR) | | 382-690 | | | 2,324-2,511 | 1,053 | 233-810 (431) | 289-384 (325) |
| PTR % body L. | 32.8* | 28-36 | 31.6* | 13.5* | 33.1* | 34.1 | 17.8-37.6 (25) | 19.4-24.2 (21.9) |
| Eggs | 60-72 × 33-35 | 53-70 × 29-39 | 49-60 × 32-42 | 56-66 × 33-36 | 54-72 × 30-42 | 51-58 × 26-35 | 52-72 × 26-46 | 64-75 × 27-44 |
| Mean | | | | | | (54 × 32) | (62 × 37) | (69 × 34) |
| Genital pore from anterior extremity | | | | | | 180 | 96-144 (121) | 124-133 (129) |
| Above as % body L. | 6.7* | 4.9* | 7.8 | | 4.8* | 5.8 | 5.9-9.9 (7.3) | 8.4-9.0 (8.7) |

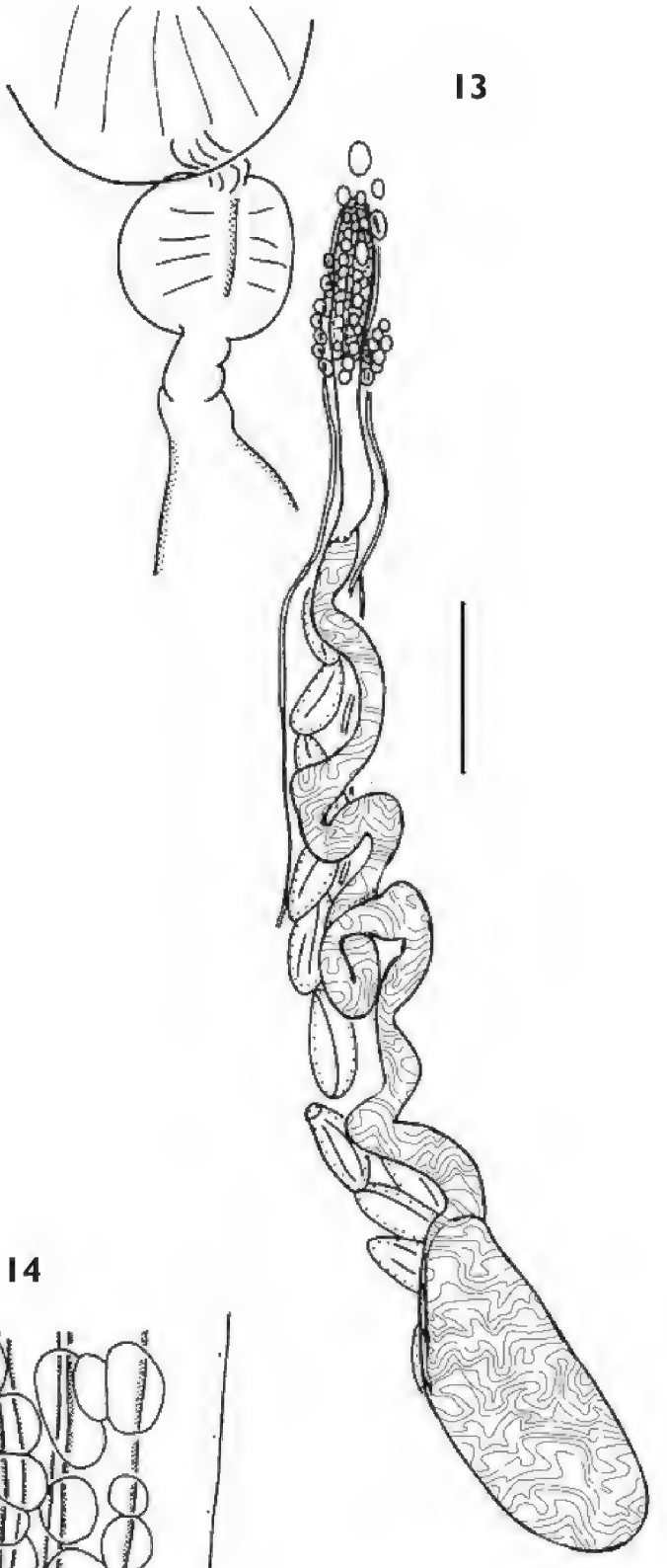
NB. ¶, calculated from published values; * values obtained from measuring drawings directly.

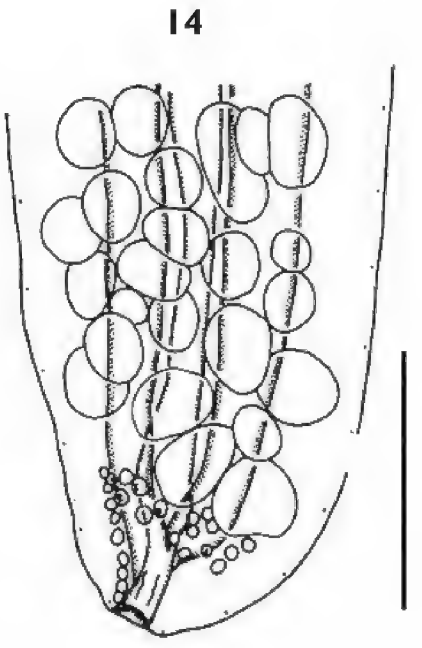
**Table 3.** Measurements of two specimens of *Pseudopecoeloides lesteri* sp. n. from *Pseudocaranx wrighti* off North Mole, Western Australia.

| | **Min.** | **Max.** | **Mean** |
|---|---|---|---|
| Length | 1,563 | 1,728 | 1,646 |
| Width | 180 | 199 | 190 |
| Length/Width | 7.9 | 9.6 | 8.7 |
| Pharynx length | 75 | 83 | 79 |
| Pharynx width | 83 | 91 | 87 |
| Ovary length | 79 | 89 | 84 |
| Ovary width | 77 | 85 | 81 |
| Anterior testis length | 145 | 171 | 158 |
| Anterior testis width | 112 | 147 | 130 |
| Posterior testis length | 152 | 196 | 174 |
| Posterior testis width | 111 | 147 | 129 |
| Forebody L. | 267 | 340 | 304 |
| Forebody % body L. | 15.5 | 21.8 | 18.6 |
| Oral sucker L. | 89 | 100 | 95 |
| Oral sucker W. | 89 | 96 | 93 |
| O.S. W/Ph. W. | 1.1 | 1.1 | 1.1 |
| Ventral sucker length | 98 | 104 | 101 |
| Ventral sucker width | 125 | 127 | 126 |
| VS width /OS width | 1.3 | 1.4 | 1.4 |
| Ventral sucker peduncle length | 224 | 224 | 224 |
| Ventral sucker peduncle width | 170 | 170 | 170 |
| Genital pore from anterior extremity | 142 | 163 | 153 |
| Above as % body L. | 8.2 | 10.4 | 9.3 |
| Seminal vesicle length | 106 | 153 | 130 |
| Seminal vesicle width | 51 | 75 | 63 |
| Intestinal bifurcation to ventral sucker | 76 | 76 | 76 |
| Post-testicular region | 386 | 448 | 417 |
| Above as % body L. | 24.7 | 25.9 | 25.3 |
| Vitellarium from anterior extremity | 545 | 548 | 547 |
| Above as % body L | 31.7 | 34.9 | 33 |
| Vitellarium from posterior extremity | 17 | 27 | 22 |
| Eggs 56-76 (67) × 25-42 (33) (n=8) | | | |

Body elongate, broader and more rounded at posterior than anterior end; maximum width in region of gonads, 2,161-4,152 (3,361) × 210-347 (280); width to length ratio 1:9.3-14.0 (12.0). Oral sucker ventrally subterminal, subspherical, 129-221 (165) × 114-179 (145). Ventral sucker pedunculate, close to anterior end, smaller than oral sucker, 73-94 (84) × 82-108 (91); sucker width ratio 1:0.5-0.7 (0.6). Ventral sucker peduncle 302-657 (484) × 106-131 (120), 10.3-16.7 (14.4) % of body length. Forebody short, with numerous gland cells, 288-409 (344) long, 8.9-14.6 (10.4) % of body length; ventral sucker peduncle to forebody length ratio 1:0.60-0.96 (0.73). Prepharynx distinct, very short, with posterior end surrounded by gland cells. Pharynx




**Figs 12-14.** *Pseudopecoeloides arripi* sp. n. ex *Arripis georgiana*. 12. Whole-mount latero-ventral view. 13, Terminal genitalia. 14. Ventral view of posterior end showing uroproct. *Scale bars*: 12, 500 µm; 13, 14, 100 µm.

well developed, spherical to subspherical, with gland cells along posterior margin, 59-105 (85) 70-109 (94); pharynx to oral sucker width ratio 1:1.4-1.8 (1.5). Oesophagus short, well developed, usually curved or looped. Intestinal bifurcation usually dorsal to ventral sucker, occasionally level with anterior margin of ventral sucker peduncle (n=1), 25-67 (49) posterior to anterior margin of ventral sucker peduncle. Caeca long, thick-walled, unite with excretory vesicle to form uroproct.

Testes 2, entire, subspherical, always separate, tandem, in posterior half of body; anterior 199-367 (298) × 145-254 (203); posterior 235-426 (339) × 151-282 (214). Post-testicular region moderately long, 633-1,323 (1,054) long, 27.8-38.2 (31.4) % of body length. Cirrus-sac absent. Seminal vesicle long, naked, sinuous, tubular and narrow anteriorly, large and saccate posteriorly; posterior portion 112-332 (224) × 55-142 (95). Pars prostatica distinct, surrounded by gland cells. Ejaculatory duct indistinct. Genital atrium small. Genital pore close to anterior end, antero-sinistral to intestinal bifurcation, at point slightly posterior to pharynx, 155-220 (190) from anterior end, 4.5-7.2 (5.8) % of body length.

Ovary pre-testicular, entire, subspherical, usually separated from anterior testis, sometimes contiguous (n=6), 81-199 (153) × 75-180 (135). Mehlis' gland distinct, antero-dorsal and dorsal to ovary. Uterine seminal receptacle usually in posterior loops of uterus, with uterus sometimes almost completely full of sperm (n=3). Uterus coils between anterior margin of ovary and region of seminal vesicle, overlaps caeca ventrally then passes anteriorly dorsal to or alongside seminal vesicle to genital pore without coiling; anterior portion of uterus sometimes crammed with eggs and greatly distended (n=3); uterine coils more concentrated posteriorly. Metraterm distinct, short; anterior extremity surrounded by gland cells. Eggs oval, operculate, tanned, sometimes malformed (n=3), 51-74 (59) × 20-39 (28). Vitelline follicles entirely posterior to ventral sucker peduncle, extend from 554-1,018 (747) from anterior extremity, 18.8-25.8 (22.0) % of body length, to 14-70 (42) from posterior extremity, with bilateral interruptions in areas adjacent to testes and sometimes in area just anterior to ovary; fields confluent dorsally and ventrally in post-testicular area, confluent or almost so in inter-testicular area and dorsally in uterine area, separate ventrally; follicles lie lateral, dorsal and ventral to caeca with anterior extent usually variously between anterior and posterior margins of enlarged posterior portion of seminal vesicle, occasionally level with (n=1) or just posterior to seminal vesicle (n=1).

Excretory pore terminal. Excretory vesicle I-shaped, long; posterior end forms narrow duct surrounded by gland cells; broader anterior portion extends anteriorly to about mid-body overlapping posterior half of ovary dorsally.

**Etymology**: This species is named after *Arripis* Jenyns, 1840 the host genus.

**Comments:** The material off South Australia is similar to that off Western Australia; however, a few differences worth noting were observed. The specimens from Western Australia are generally larger than those from South Australia, with a slightly longer forebody, but the ventral sucker of the latter is larger relative to the oral sucker. The most significant of these difference is the difference in the size of the ventral sucker, which may relate to the allometric growth of the worms, although it is possible that different species are involved.

*Pseudopecoeloides arripi* sp. n. can be accommodated in Group A and distinguished from the other species in the group by being less elongate than *P. tenuis* and *P. hickmani* sp. n. but more elongate, as shown by the width to length ratio, with a longer post-testicular area than *P. psettodi, P. capucini* and *P. wekeula* (Table 1), and by having a shorter post-testicular region than *P. tenuis*, relative to the body length. The new species has a forebody shorter than *P. capuccini* and *P. wekeula* but longer than *P. tenuis*, *P.*

**Table 4.** Measurements of 6 specimens of *Pseudopecoeloides arripi* sp. n. from *Arripis georgianus* off Kingscote, South Australia.

| | **Min.** | **Max.** | **Mean** |
|---|---|---|---|
| Length | 1,596 | 2,798 | 2,138 |
| Width | 156 | 213 | 182 |
| Length/Width | 8.7 | 15 | 11.8 |
| Pharynx length | 59 | 82 | 68 |
| Pharynx width | 67 | 81 | 73 |
| Ovary length | 50 | 120 | 89 |
| Ovary width | 46 | 102 | 77 |
| Anterior testis length | 152 | 233 | 190 |
| Anterior testis width | 120 | 177 | 146 |
| Posterior testis length | 154 | 249 | 198 |
| Posterior testis width | 137 | 183 | 156 |
| Forebody L. | 248 | 337 | 285 |
| Forebody % body L. | 9.6 | 17 | 13.9 |
| Oral sucker L. | 91 | 143 | 112 |
| Oral sucker W. | 88 | 120 | 103 |
| O.S. W/Ph. W. | 1.3 | 1.6 | 1.4 |
| Ventral sucker length | 75 | 96 | 88 |
| Ventral sucker width | 83 | 108 | 98 |
| VS width /OS width | 0.7 | 1.1 | 1.0 |
| Ventral sucker peduncle length | 271 | 458 | 338 |
| Ventral sucker peduncle width | 98 | 156 | 124 |
| Ventral sucker peduncle % body L. | 12.2 | 18.2 | 15.6 |
| Forebody/peduncle length ratio | 0.59 | 1 | 0.87 |
| Genital pore from anterior extremity | 121 | 178 | 148 |
| Above as % body L. | 5.8 | 9.6 | 7.1 |
| Seminal vesicle length | 69 | 190 | 135 |
| Seminal vesicle width | 27 | 87 | 58 |
| Intestinal bifurcation to ventral sucker | 11 | 37 | 21 |
| Post-testicular region | 366 | 787 | 584 |
| Above as % body L. | 22.9 | 30.5 | 27.2 |
| Vitellarium from anterior extremity | 414 | 661 | 502 |
| Above as % body L. | 20.6 | 25.9 | 23.8 |
| Vitellarium from posterior extremity | 15 | 32 | 24 |
| Eggs 47-67 (56) x 21-36 (28) (n=41) | | | |

*psettodi* and *P. hickmani* sp. n. relative to the body length, and a larger pharynx relative to the oral sucker than *P. tenuis* and *P. psettodi*. Furthermore, *P. arripi* sp. n. has larger eggs than *P. hickmani* sp. n. and its body tapers only slightly and ends abruptly in a rounded posterior end, whereas in the latter it tapers gradually to a rather pointed extremity. *P. arripi* sp. n. is closest to *P. opelu* but can be distinguished from it by its slightly larger pharynx to oral sucker width ratio of 1:1.4-1.8 (1.5) versus 1:1.8 and its longer post-testicular region relative to the body length. These two species can further be separated by the more anterior position of the intestinal bifurcation in the new species, being at the level of the anterior margin of the ventral sucker peduncle rather than as it is in *P. opelu*.

Because the size of the pharynx of *Pseudopecoeloides arripi* sp. n. and *P. opelu* overlap, the main basis for separating these two species is the non-overlapping size of the post-testicular region, which we consider to be significant in species of *Pseudopecoeloides*. In addition, it is noteworthy that *P. opelu* is known only from a carangid, the mackerel scad *Decapterus macarellus*, off Hawaii (Yamaguti, 1970).

***Pseudopecoeloides atherinomori* Aken'Ova, Cribb & Bray, sp. n.**
urn:lsid:zoobank.org:act:F5CF0AD3-5D8E-4C2B-BD09-FBF75D31088B

**Type-host:** *Atherinomorus ogilbyi* (Whitley) (Atherinidae, Atheriniformes), Ogilby's hardyhead.

**Type-locality:** Moreton Bay, South-East Queensland, 27°20'S, 153°07'E, March 1989.

**Other localities:** Off Dunwich, Stradbroke Island; 27°30'S, 153°24'E, January and November 1994; Off Bribie Island, South-East Queensland 27°00'S, 153°05'E.

**Site:** Intestine.

**Material studied:** Ex *Atherinomorus ogilbyi*: 6 from Moreton Bay; 2 from off Dunwich, Stradbroke Island, (one of the specimens was unmounted and sectioned after measuring); 1 from off Bribie Island from a pooled gut-wash.

**Type-material:** Holotype: Queensland Museum, Reg. No. QM G230489, paratypes: Queensland Museum, Reg. Nos. QM G230490-230494, BMNH Reg. Nos 2008.12.9.28-29.

**Description** (Figures 15-18): Based on 6 gravid, 2 immature laterally mounted specimens, 1 dorso-ventrally mounted specimen and 1 set of sagittal serial sections. Measurements are of 6 gravid, unflattened, laterally mounted worms.

Body elongate, slender, subcylindrical; maximum width in region of gonads, 1,312-2,155 (1,677) × 146-194 (176); width to length ratio 1:7.5-12.1 (9.6). Oral sucker ventrally subterminal to nearly terminal, spherical to subspherical, 84-130 (106) × 84-120 (104). Ventral sucker larger than oral sucker, spherical to subspherical, on very short peduncle; peduncle forms wrinkles around ventral sucker in dorso-ventrally mounted worm, 117-175 (142) × 117-149 (134); sucker width ratio 1:1.2-1.4 (1.3). Forebody relatively short, contains numerous large and small gland cells, 214-292 (258) long, 13.3-20.7 (15.8) % of body length. Prepharynx distinct, short.

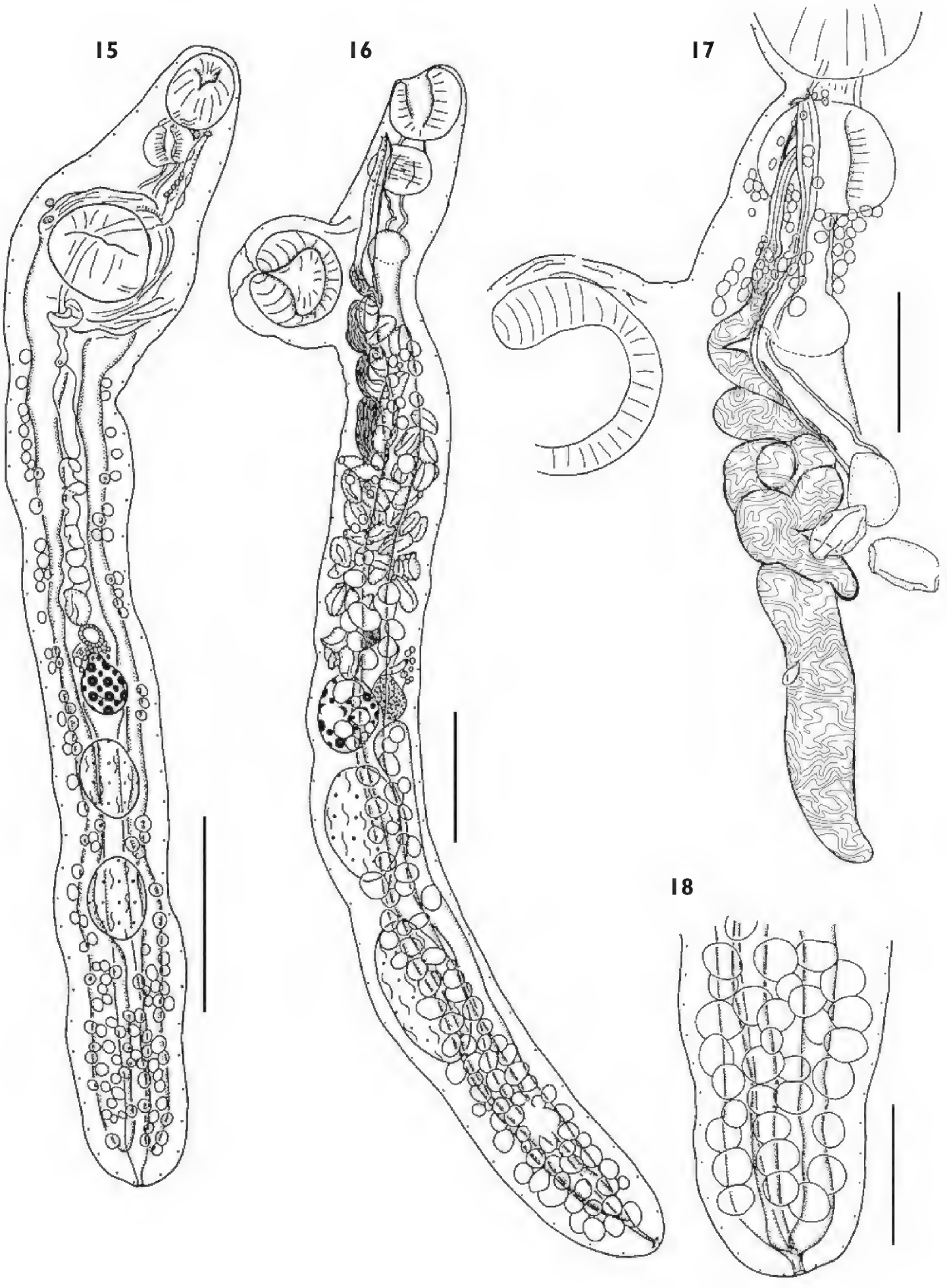



**Fig. 15-18.** *Pseudopecoeloides atherinomori* sp. n. ex *Atherinomorus ogilbyi*. 15. Whole-mount ventral view. 16. Whole-mount lateral view. 17. Terminal genitalia. 18. Ventral view of posterior end showing uroproct. *Scale bars*: 15, 16, 250 µm; 17, 18, 100 µm.

Pharynx large, subspherical, with numerous gland cells along posterior margin, 62-84 (70) × 71-100 (85); pharynx to oral sucker width ratio 1:1.2-1.4 (1.2). Oesophagus moderately long, surrounded by gland cells. Intestinal bifurcation, dorsal to ventral sucker, 13-48 (32) posterior to anterior margin of ventral sucker. Caeca long, open into excretory vesicle close to posterior extremity to form uroproct.

Testes 2, entire, elongate-oval, usually separate, occasionally contiguous (n=1), tandem, in posterior half of body; anterior 91-188 (142) × 61-143 (101); posterior 97-240 (162) × 71-123 (102). Post-testicular area 233-810 (431) long, 17.8-37.6 (25.0) % of body length. Cirrus-sac absent. Seminal vesicle naked, long, tubular, sinuous to convoluted at anterior end, elongate and saccular at posterior end, extends from region of intestinal bifurcation to point posterior to ventral sucker. Pars prostatica distinct, surrounded by gland cells. Ejaculatory duct moderately long, thick-walled, surrounded by gland cells. Genital atrium doliiform, thick-walled. Genital pore sinistrally submedian, anterior to intestinal bifurcation, level with or slightly anterior to anterior margin of pharynx, 96-144 (121) from anterior end, 5.9-9.9 (7.3) % of body length.

Ovary pre-testicular, entire, subspherical, 75-143 (100) × 65-113 (85). Mehlis' gland distinct, antero-dorsal to ovary. Uterine seminal receptacle present. Laurer's canal distinct, long, convoluted, thick-walled, opens at point dorso-sinistral to ovary. Uterus coils between anterior margin of ovary and region of posterior margin of ventral sucker, runs without coiling alongside anterior portion of seminal vesicle to unite with ejaculatory duct close to genital pore. Metraterm distinct. Eggs large, oval, operculate, 52-72 (62) × 26-46 (37). Vitelline follicles extend from 318-459 (389) from anterior extremity, 19.6-31.5 (23.7) % of body length, to 13-39 (28) from posterior extremity; fields confined to hindbody extending from about level of posterior margin of ventral sucker almost to posterior extremity, confluent dorsally and ventrally in post-testicular area, with follicles lateral, ventral, and dorsal to caeca.

Excretory pore terminal. Excretory vesicle I-shaped; narrow terminal portion surrounded by gland cells; vesicle widens and passes anteriorly to terminate at about mid-body.

**Etymology:** The species name is derived from *Atherinomorus* Fowler, 1903 the host genus.

**Comments:** The nature of the caecal ends in this species is very difficult to discern. The caeca appear to terminate blindly in the single dorso-ventrally mounted specimen, whereas they clearly open into the excretory vesicle in one of the eight laterally mounted specimens. Madhavi (1975) and Bray (1987) also had trouble in determining the relationship between the caeca and the excretory vesicle in a related species. This is discussed in the footnote attached to *P. scomberi*. Although Bray (1987) suggested that sectioning would solve the problem, it did not do so in the present material. However, we have concluded that the present species has a uroproct, based on observations on the single laterally mounted specimen (Figure 18).

*Pseudopecoeloides atherinomori* sp. n. can be accommodated in Group B (Table 2): *P. akule* has a smaller ventral sucker and pharynx relative to the oral sucker. *P. scomberi* is slightly more elongate, with a width to length ratio of 1:12.8 versus 1:7.5-12.1

(9.6); it also has a smaller ventral sucker and pharynx relative to the oral sucker and a shorter forebody relative to the body length (Table 2). *P. atherinomori* sp. n. resembles *P. lesteri* sp. n. in most metrical features but can be distinguished from the latter by its shorter forebody and slightly longer post-testicular area relative to the body length. Furthermore, the anterior limit of the vitelline follicles in *P. atherinomori* is about level with the posterior margin of the ventral sucker peduncle, whereas it is about half-way between the anterior margin of the ovary and the posterior margin of the ventral sucker peduncle in *P. lesteri* sp. n. *P. atherinomori* sp. n. also resembles *P. carangis* in its vitelline distribution and in some metrical features, but the latter has a smaller ventral sucker and a smaller pharynx relative to the oral sucker.

***Pseudopecoeloides hafeezullahi* Aken'Ova, Cribb & Bray, sp. n.**
urn:lsid:zoobank.org:act:082BE7F1-0E25-4406-B637-2173BBCB0BB8

**Type-host:** *Trachurus novaezealandiae* (Richardson) (Carangidae: Perciformes), yellowtail horse mackerel.

**Type-locality:** Off Coogee Beach Jetty, Western Australia, 32°07' S, 115°46'E, November 1994.

**Other locality:** Off Cockburn Breakwall (Shipyards), Fremantle, Western Australia, 32°11'S, 115°47'E, December 1994.

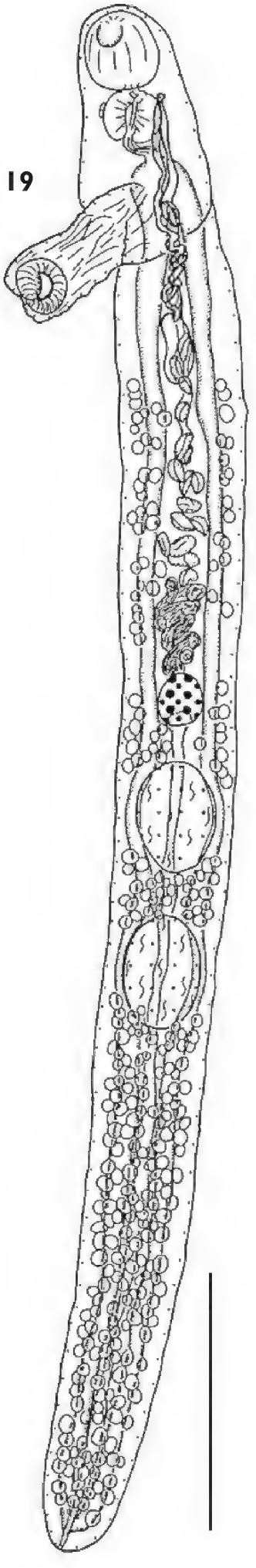
**Site:** Intestine.

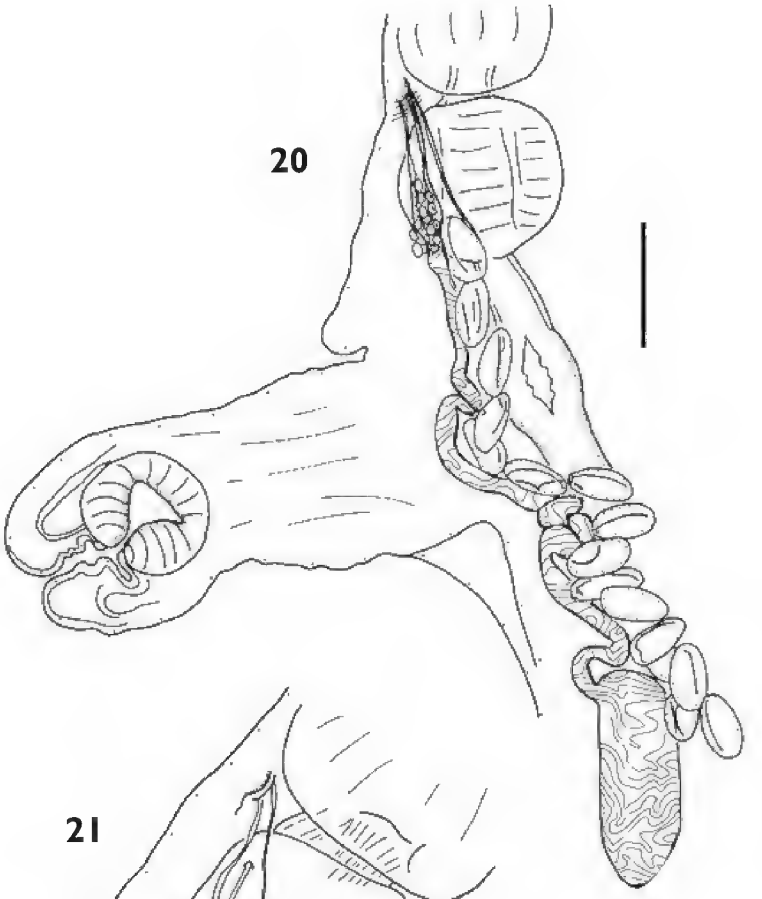
**Material studied:** 7 off Coogee Beach Jetty; 5 off Cockburn Breakwall.

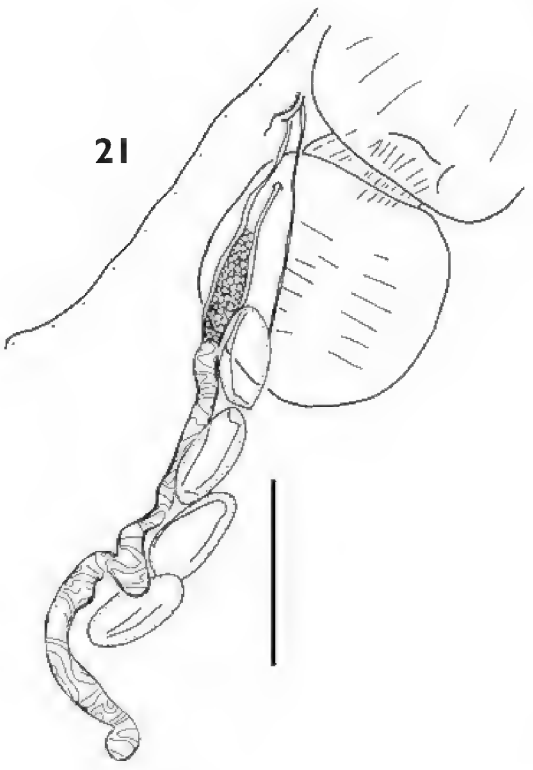
**Type-material:** Holotype: Queensland Museum, Reg. No. QM G230495, paratypes: Queensland Museum, Reg. Nos QM G230496-230515, BMNH Reg. Nos 2008.12.9.31-43.

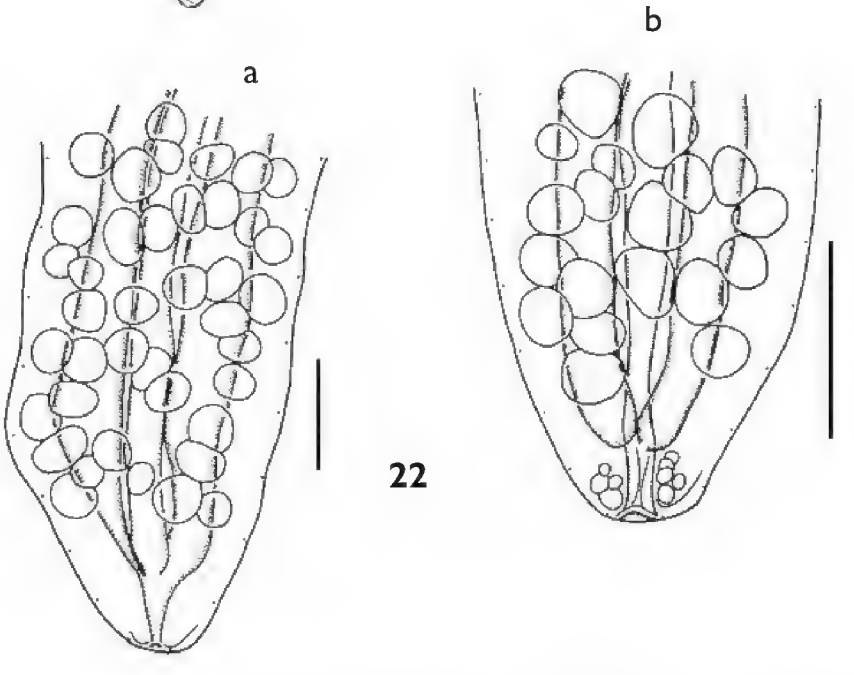
**Description** (Figures 19-22): Description based on 11 gravid, unflattened, laterally and dorso-ventrally mounted specimens and 1 immature specimen. Measurements are of 10 gravid, unflattened, laterally mounted worms.

Body elongate, subcylindrical, rounded at anterior and posterior ends, 2,452-3,564 (3,026) × 226-321 (274); width almost uniform; maximum width in area of uterus and gonads; width to length ratio 1:8.9-12.6 (11.1). Oral sucker spherical to subspherical, ventrally subterminal, 128-163 (147) × 110-169 (141). Ventral sucker pedunculate, close to anterior end, slightly smaller than oral sucker, subspherical, 85-111 (96) × 96-110 (105); sucker width ratio 1:0.6-0.9 (0.7). Ventral sucker peduncle long, broad, 289-382 (330) × 129-161 (140), length 10.1-11.8 (10.9) % of body length. Forebody short, containing gland cells, 299-465 (384) long, 11.0-15.3 (12.9) % of body length; peduncle to forebody length ratio 1:1.0-1.3 (1.2). Prepharynx distinct, short. Pharynx large, spherical to subspherical, 85-115 (99) × 99-122 (111); pharynx to oral sucker width ratio 1:1.1-1.4 (1.3). Oesophagus distinct, short, well developed. Intestinal bifurcation usually dorsal to ventral sucker peduncle, 15-40 (27) posterior to anterior margin of ventral sucker, occasionally level with anterior margin of ventral sucker peduncle (n=1). Caeca long, narrow, thick-walled,




**Figs 19-22.** *Pseudopecoeloides hafeezullahi* sp. n. ex *Trachurus novaezealandiae*. 19. Whole-mount latero-ventral view. 20. Terminal genitalia. 21. Anterior part of terminal genitalia. 22 (a,b) Ventral view of posterior end showing uroproct. *Scale bars*: 19, 500 µm; 20, 21, 22, 100 µm.

open into excretory vesicle close to posterior extremity to form uroproct. Excretory pore terminal. Excretory vesicle I-shaped, overlaps ovary dorsally to point just anterior to its posterior margin.

Testes 2, entire, subspherical, separate, tandem, in posterior half of body; anterior 183-284 (226) × 122-205 (162); posterior 197-295 (235) × 130-202 (160). Post-testicular area 797-1,159 (971) long, 28.0-34.2 (32.1) % of body length. Cirrus-sac absent. Seminal vesicle long, tubular, narrow and sinuous anteriorly, large and saccular posteriorly, extends from about level of posterior margin of pharynx to point variously posterior to ventral sucker peduncle; saccular posterior portion 107-213 (158) × 51-68 (59). Pars prostatica distinct, well developed, surrounded by gland cells. Ejaculatory duct short. Genital atrium large, tubular. Genital pore extracaecal, close to anterior extremity, antero-sinistral to intestinal bifurcation, may be level with, slightly anterior to or slightly posterior to anterior margin of pharynx, 142-181 (166) from anterior end, 4.6-6.7 (5.5) % of body length.

Ovary pre-testicular, entire, subspherical, 85-134 (104) × 76-123 (94). Mehlis' gland distinct, antero-dorsal to ovary. Uterine seminal receptacle present. Laurer's canal present, opens antero-sinistrally to ovary, dorsal to left caecum. Uterine coils extend between anterior margin of ovary and abour level of posterior margin of seminal vesicle, overlapping caeca slightly, follows course of seminal vesicle, unites with ejaculatory duct close to its anterior extremity and leads to genital pore as single duct. Metraterm indistinct. Eggs oval, operculate, 40-60 (52) × 20-37 (26). Vitelline follicles restricted to hindbody, extend from 624-962 (788) from anterior extremity, 22.7-30.8 (26.1) % of body length, to 45-88 (60) from posterior extremity; fields confluent dorsally and ventrally in post-testicular and inter-testicular regions, more or less confluent between anterior margin of anterior testis and anterior limit dorsally, separate ventrally, with follicles lateral, dorsal and ventral to caeca, with few follicle-free patches especially in regions of gonads and uterus; anterior limit usually at various points posterior to seminal vesicle, occasionally level with (n=2) or just anterior to posterior margin of seminal vesicle (n=2).

**Etymology:** This species is named for M. Hafeezullah in recognition of his contribution to the taxonomy of opecoelids.

**Comments:** *Pseudopecoeloides hafeezullahi* sp. n. fits the concept of Group A. It can be distinguished immediately from other species in the group by having the largest pharynx relative to the oral sucker, but it can further be differentiated as follows (Table 1). *P. tenuis* and *P. hickmani* sp. n. are more elongate species with shorter forebodies and longer post-testicular areas relative to the length of the body; additionally, *P. hickmani* sp. n. has a longer forebody relative to the body length. *P. capucini* and *P. wekeula* are less elongate with slightly shorter forebodies, *P. psettodi* has a shorter forebody and post-testicular area relative to the body length and *P. wekeula* has a cirrus-sac whereas *P. hafeezullahi* sp. n. does not. The new species is quite similar to *P. opelu* and *P. arripi* n. sp, but it can be distinguished by the longer post-testicular area compared with *P. opelu*, the slightly longer forebody than *P. arripi* sp. n. and by the longer ventral sucker peduncle, all relative to the body length (Tables 1, 4).

***Pseudopecoeloides scomberi* Hafeezullah, 1971**
(Syn. *Pseudopecoelus scomberi* (Hafeezullah, 1971) Madhavi, 1975)

**Host:** *Scomberoides lysan* (Forsskål) (Carangidae: Perciformes), doublespotted queenfish.

**Locality:** off Dunwich, Stradbroke Island, Queensland, 27°30'S, 153°24'E, February 1994.

**Site:** Intestine.

**Material studied:** 1 specimen.

**Voucher specimen:** Queensland Museum, Reg. No. QM G230516.

**Description** (Figures 23-24): Based on single gravid, unflattened, laterally mounted worm.

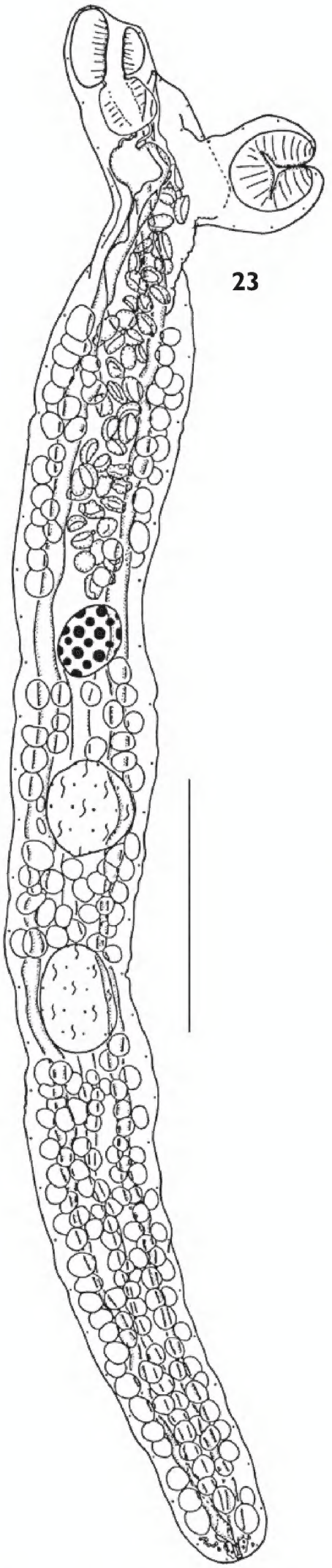
Body elongate, slender, subcylindrical; maximum width in region of gonads, 3,088 × 288; width to length ratio 1:10.7. Oral sucker ventrally subterminal, subspherical, 154 × 141. Ventral sucker close to anterior end, larger than oral sucker, subspherical, on very short peduncle, 167 × 148, sucker width ratio 1:1. Forebody short, contains gland cells, 298 long, 9.7% of body length. Pharynx large, spherical, 103 × 103; pharynx to oral sucker width ratio 1:1.4. Oesophagus distinct, short. Intestinal bifurcation, dorsal to ventral sucker. Caeca long, open into excretory vesicle close to posterior extremity to form uroproct (Figure 24).

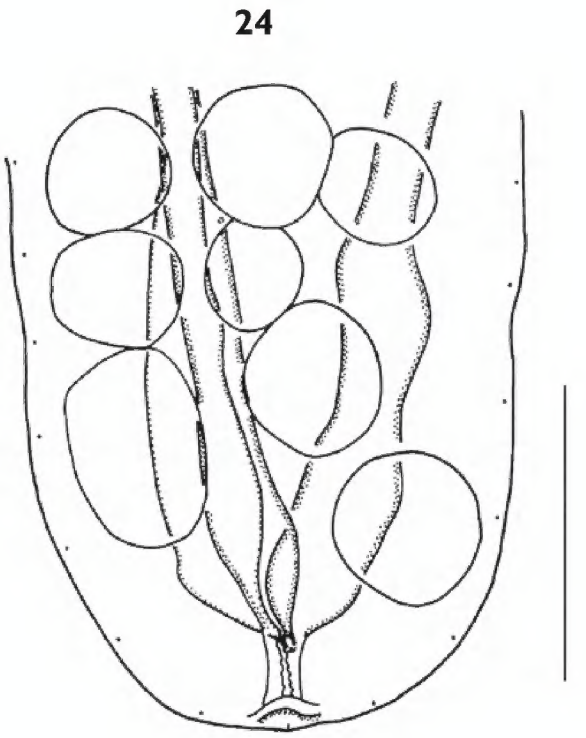
Testes 2, entire, subspherical, separate, tandem, in anterior part of posterior half of body; anterior 193 × 167; posterior 135 × 298. Post-testicular area 1,053 long, 34.1% of body length. Prepharynx distinct, short. Cirrus-sac absent. Seminal vesicle naked, long, tubular, elongate and saccular at posterior end, extends from about level of intestinal bifurcation to level posterior to ventral sucker. Ejaculatory duct relatively short. Genital atrium small. Genital pore sinistrally submedian, anterior to intestinal bifurcation, level with posterior margin of pharynx, 180 from anterior end, 5.8% of body length.

Ovary pre-testicular, entire, subspherical, 141 × 116. Uterine seminal receptacle apparently present. Uterus coils between anterior margin of ovary and point dorsal to ventral sucker. Metraterm indistinct. Eggs large, oval, operculate, 51-58 (54) × 26-35 (32). Vitelline follicles extend from 578 from anterior extremity, 18.7% of body length, to 32 from posterior extremity; fields confined to hindbody, extending from level posterior to ventral sucker almost to posterior extremity, confluent dorsally and ventrally in post-testicular area; lateral, ventral and dorsal to caeca, with bilateral interruptions adjacent to testes and ovary.

Excretory pore terminal. Excretory vesicle I-shaped; narrow terminal portion surrounded by gland cells; vesicle widens and passes anteriorly to overlap posterior margin of ovary.

**Comments:** *Pseudopecoeloides scomberi* was described and figured, from the needlescaled queenfish *Somberoides tol* (Cuvier) in the Gulf of Mannar, as having a uroproct (Hafeezullah, 1971). Madhavi (1975) examined worms from the same host and locality and concluded that the species belonged in *Pseudopecoelus* von Wicklen, 1946, in which the caeca end blindly, as she did not observe a uroproct in either whole-mounts




**Figs 23-24.** *Pseudopecoeloides scomberi* Hafeezullah, 1971 ex *Scomberoides lysan.* 23. Whole-mount latero-ventral view. 24. Ventral view of posterior end showing uroproct. *Scale bars*: 23, 500 µm; 24, 100 µm.

or sections. Bray (1987) also examined two whole-mounted museum specimens of this species from the barred queenfish *S. tala* (Cuvier) off India, and two specimens from *S. tol* off Malaysia, but could not detect a uroproct. Madhavi (1975) stated that "the ends of the caeca establish close contact with the bladder but apparently do not open into it". We interpret Madhavi's observation to mean that she was still not quite certain as to the presence or absence of a uroproct.

The specimen from *Scomberoides lysan* is almost identical in every metrical feature and in general appearance to those described by Hafeezullah (1971) from *S. tol*, except as follows. The vitelline follicles in the present material are interrupted bilaterally in areas adjacent to the gonads, whereas they are continuous in Hafeezullah's material, although, in his figure of the worm, the vitelline follicles thin out around the gonads. Hafeezullah's worms are also much larger than the present material, being 6,828-7,056 × 504-583 compared with 3,088 × 288 (Table 2). Since the present report is based on a single specimen, it was not possible to assess variation in the vitelline distribution or size in this species. The "inconspicuous cirrus-sac" observed by Hafeezullah (1971) in *P. scomberi* was not seen in the present material. Although the occurrence of a vestigial cirrus-sac is not characteristic of most species of *Pseudopecoeloides*, it does not preclude the inclusion of *P. scomberi* in the genus, since it was observed by Yamaguti (1970) in some specimens of *P. akule* and in *P. wekeula*. Madhavi (1975) considered Hafeezullah's material to be a species of *Pseudopecoelus* but, because of the observations we have made regarding the caecal ends in the present material (Figure 24) and the fact that these worms are practically indistinguishable morphologically, we are treating the present material and Hafeezullah's as conspecific. Moreover, their hosts are congeners. The presence of a uroproct necessitates the return of this species to *Pseudopecoeloides*.

## Discussion

The above descriptions of five new species brings the total of species in this genus to 23 and creates the opportunity for some review of host-specificity within the genus. Firstly, it must be stated that it is unlikely that all the existing records in the literature are correct. It is striking that there are at least eight families and about 20 species of fishes reported as hosts for *Pseudopecoeloides carangis* and, although it is possible, this contrasts with the much narrower specificity reported for most other species. Most probably identification has been made several times on the basis of a broad similarity rather than a precise determination. Secondly, it is clear that the Carangidae is the dominant host family for species of *Pseudopecoeloides*; 11 of the species are reported from this family. The Mullidae (five species), Priacanthidae (three species) and Champsodontidae (three species) are also relatively rich. Finally, there are now five fish species that are reported to harbour at least two (and up to 3) species of *Pseudopecoeloides*: Carangidae – *Pseudocaranx wrighti* and *Selar crumenophthalmus*; Champsodontidae – *Champsodon capensis;* Mullidae – *Parupeneus macronema;* and Priacanthidae – *Cookeolus boops* and *Heteropriacanthus cruentatus*. In some cases these multiple infections may

be pointers to possible synonymy but also to a possible rapid evolutionary expansion among certain host groups.

## Acknowledgements

We thank the Australian and Nigerian governments, Ahmadu Bello University, Zaria, Nigeria and ABRS (Australian Biological Resources Study) for financial assistance. We also thank Alistair Dove, Trudy Wright, Scott Burge and Sylvie Pichelin for assistance in the field.

## References

Aken'Ova TO (2003) *Dactylomyza gibsoni* n. g., n. sp. (Digenea: Opecoelidae) from *Schuettea woodwardi* (Waite) (Monodactylidae) from off Western Australia. Systematic Parasitology 55: 61-65.

Bartoli P, Bray RA, Gibson DI (2003) Opecoelidae (Digenea) from western Mediterranean fishes: three rare species. Systematic Parasitology 55: 81–95.

Bray RA (1987) Some helminth parasites of marine fishes of South Africa: family Opecoelidae (Digenea). Journal of Natural History 21: 1049-1075.

Bray RA, Justine J-L (2008) *Dupliciporia lanterna* sp. n. (Digenea: Zoogonidae) from *Priacanthus hamrur* (Perciformes: Priacanthidae) and additional zoogonids parasitizing fishes from the waters off New Caledonia. Zootaxa 1707: 60-68.

Fischthal JH, Thomas JD (1970) Digenetic trematodes of marine fishes from Ghana: Family Opecoelidae. Proceedings of the Helminthological Society of Washington 37: 129-141.

Hafeezullah M (1971) Opecoelid trematodes of marine fishes of India. Parasitology 62: 321-329.

Korotaeva VD (1971) [Some helminth fauna of commercial marine fishes of sub-order Trichuroidei in the Australia – New Zealand region]. Izvestiya Tikhookeanskogo Nauchno Issledovatel'skogo Instituta Rybnogo Khozyaistva i Okeanografii (TINRO) 75: 69-84. (In Russian).

Korotaeva VD (1975) Contribution to the fauna of helminths and parasitic crustaceans of marine commercial fishes of the Australian and New Zealand waters. Trudy Biologo-Pochvennogo Instituta Novaya Seriya 26: 46-60. (In Russian).

Lebedev BI (1968) [Helminth fauna of carangid fish in the Pacific Ocean]. Soobshcheniya Dal'nevostchnogo Filiala im. B.L. Komarova Akademii Nauk SSSR 26: 80-85. (In Russian).

Madhavi R (1975) Digenetic trematodes from marine fishes of Waltair Coast, Bay of Bengal. Family Opecoelidae. Rivista di Parassitologia 36: 153-164.

Manter HW (1947) The digenetic trematodes of marine fishes of Tortugas, Florida. American Midland Naturalist 38: 257-416.

Manter HW (1954) Some digenetic trematodes from fishes of New Zealand. Transactions of the Royal Society of New Zealand 82: 475-568.

Martin WE (1960) Hawaiian helminths, Part III. New opecoelid trematodes. Pacific Science, 14, 411-415.

Parukhin, AM (1983) [New species of trematodes from commercial fishes of the Indian Ocean.] Zoologicheskii Zhurnal 62: 1106-1108. (In Russian).

Roff JC, Hopcroft RR (1986) High precision microcomputer based measuring system for ecological research. Canadian Journal of Fisheries and Aquatic Sciences 43: 2044-2048.

Shen J-W (1990) Digenetic trematodes of marine fishes from Hainan Island. Science Publications, Beijing, 228 pp. (In Chinese, English summary).

Toman G (1992) Digenetic trematodes of marine teleost fishes from the Seychelles, Indian Ocean. III. Acta Parasitologica 37: 119-126.

Yamaguti S (1938) Studies on the helminth fauna of Japan. Part 21. Trematodes of fishes, IV. Satyû Yamaguti, Kyoto, 139 pp.

Yamaguti S (1940) Studies on the helminth fauna of Japan, Part 31. Trematodes of fishes, VII. Japanese Journal of Zoology 9: 35-108.

Yamaguti S (1970) Digenetic trematodes of Hawaiian fishes. Keigaku, Tokyo, 436 pp.

Yamaguti S (1971) Synopsis of digenetic trematodes of vertebrates. Keigaku, Tokyo, Vol. I, 1074 pp.; Vol. II, 349 pp.